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WindPACT Turbine Design Scaling Studies Technical Area 2: Turbine, Rotor, and Blade Logistics

March 27, 2000 to December 31, 2000

Kevin Smith
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Executive Summary

Through the National Renewable Energy Laboratory (NREL), the United States Department of Energy (DOE) implemented the Wind Partnership for Advanced Component Technologies (WindPACT) program. This program will explore advanced technologies that may reduce the cost of energy (COE) from wind turbines. The initial step in the WindPACT program is a series of preliminary scaling studies intended to determine the optimum sizes for future turbines, help define sizing limits for certain critical technologies, and explore the potential for advanced technologies to contribute to reduced COE as turbine scales increase. This report documents the results of Technical Area 2–Turbine Rotor and Blade Logistics.

For this report, we investigated the transportation, assembly, and crane logistics and costs associated with installation of a range of multi-megawatt-scale wind turbines. We focused on using currently available equipment, assembly techniques, and transportation system capabilities and limitations to hypothetically transport and install 50-wind turbines at a facility in south-central South Dakota.

We found that, as turbine scales increase, logistics costs also increase. The application of transportation and assembly techniques (not currently used by the wind industry) to minimize costs served only to change the rate of increase and extend the point at which dramatic cost increases are incurred. The breakpoint we determined, falls between the 2500-kilowatt and 3500-kW turbines. A decrease in logistics costs to values less than those of the 750-kW turbines may not, however, be realized as turbine scale increases. The logistics costs associated with a smaller number of multi-megawatt turbines would likely be higher than those for the 50 turbines assumed in this study, and would result in breakpoints at lower megawatt turbine sizes because the fixed costs would be distributed over fewer turbines.

Tower transportation factors have the greatest influence on logistics costs. Alternative tower configurations may offer the best opportunity to reduce the overall logistical costs. Significant breakpoints occur at the 2500-kW turbine size and 80-meter hub height. Turbine designers should be aware of these points and factor in the impacts of exceeding them into the machine design.

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1. Introduction

Through the National Renewable Energy Laboratory (NREL), the United States Department of Energy (DOE) has implemented the Wind Partnership for Advanced Component Technologies (WindPACT) program. This program will explore advanced technologies for reducing the cost of energy (COE) from wind turbines. The initial step in the WindPACT program is a series of preliminary scaling studies intended to determine the optimum sizes for future turbines, help define sizing limits for certain critical technologies and explore the potential for advanced technologies to contribute to reduced COE as turbine scales increase. We identified four technical areas for examination in this initial phase; Technical Area 1, Blade Scaling; Technical Area 2, Turbine Rotor and Blade Logistics; and Technical Area 3, Self-Erecting Towers; and Technical Area 4, Balance of Station.

Global Energy Concepts, LLC (GEC), was awarded contract number YAM-0-30203-01 to examine Technical Areas 1, 2, and 3. This report documents the results of GEC's Technical Area 2 study, which includes an investigation of the transportation, assembly, and crane logistics and costs associated with installing multi-megawatt scale wind turbines. We focused on using currently available equipment, assembly techniques, and transportation system capabilities and limitations to hypothetically transport and install 50 wind turbines at a facility in south-central South Dakota.

1.1 Project Organization and Approach

To complete this work, GEC assembled a project team including experts in the areas of transportation, turbine construction and erection, and crane work. These consultants include Lampson International Ltd. (Lampson) of Kennewick, Washington; American Transport Systems (ATS) of Vineland, New Jersey; and M.A. Mortenson (Mortenson) of Minneapolis, Minnesota. Lampson has provided cranes and other equipment for several wind energy installations, including the 1.65-MW Vestas wind turbines in Texas. ATS is a nationally recognized company that handles all aspects of shipping and hauling; they have been involved the transporting wind turbine components to and from various points in the United States for several different vendors. Mortenson is a large construction company that has served as general contractor for multiple U.S. wind projects in the last few years.

GEC used the following general approach to the work:

1. Researched turbine scaling relationships, assembled information for existing megawatt-scale turbines; and used this information to compute component sizes and weights for use in evaluating transportation, crane, and assembly requirements.
2. Researched and compiled pertinent information such as (a) size, availability, and costs of large cranes and other required equipment; (b) weight and size limitations of existing transportation options including rail links, road trucking, and water transport; (c) costs and requirements for customized transport and special circumstances allowable through permitting; and (d) routing restrictions, permit requirements, and costs.
3. Considered historical experience to identify potential problem areas and build on the lessons already learned in the industry. This included reviewing historic reports related to the Boeing MOD 2 and MOD 5 turbines.

4. Solicited information from project partners on logistic approaches used in other industries and applications for objects that were comparable in scale to the multi-megawatt WindPACT turbines.
5. Contacted transportation authorities and government agencies to further qualify and quantify options and identify limitations.
6. Established a set of realistic and viable options for transportation and erection logistics and developed cost assumptions for each of these options.
7. Conducted parametric cost analysis to demonstrate the impact of turbine scale on the costs of transportation and turbine erection.
8. Evaluated the viability of nontraditional options such as field assembly of nacelle subcomponents or towers.
9. Established the purchase cost for an appropriate crane, crew requirements, mobilization, and maintenance costs, and evaluated the economics of such a purchase by amortizing these costs over the facility and others in the region.

1.2 Scope and Hypothetical Facility

We investigated the transportation, assembly, and crane logistics associated with megawatt-scale wind turbines. Construction of turbine foundations, substation, site roads, the on-site electrical grid, and other miscellaneous items were not considered in this study but were evaluated by others in the WindPACT Technical Area 4 (Balance of Station Costs) study.

We assumed that the hypothetical facility was located near Mission, South Dakota, in an area of rolling hills characterized by a wind power class of 5 to 6 (7.5 to 8.5 meters per second at 50 m). We also assumed that the 50 turbines were installed on a grid with 2D by 10D spacing [1](D corresponding to rotor diameters). The five turbine sizes evaluated in this study were 750, 1500, 2500, 3500, and 5000 kilowatts. The corresponding facility capacities were 37.5, 75, 125, 175, and 250 MW, respectively. In the following sections, we identify other assumptions as they relate to specific investigations.

[1] The WindPACT Technical Area 4-Balance of Station Costs study calculated a grid spacing of 2.3 D by 12 D based on wind resource and topography data. From a logistics perspective there is no significant difference between these grid dimension and those assumed in this logistics report.

2. Multi-megawatt Turbine Scaling

2.1 Scaling Criteria Development

In order to conduct a study into the logistics associated with multi-megawatt turbines, it was essential that reasonable estimates of turbine component dimensions and masses were derived. The basic configuration of the multi-megawatt WindPACT turbines draws heavily on the existing generation of megawatt-scale turbines. We assumed that all WindPACT turbines were three bladed, upwind, pitch-controlled turbines installed onto tubular steel towers.

We derived the component dimensions and masses for five turbine sizes from the various scaling assumptions and equations discussed below. We also performed literature searches to identify applicable documents that contain scaling equations. As part of developing the scaling relationships, a database of commercial megawatt-scale turbines was prepared to evaluate actual component masses, rotor and hub height relationships, and rotor and power relationships. We present a summary of the specifications used for the WindPACT turbines in Table 2-1 and a summary of the WindPACT tower specifications in Table 2-2. Appendix A contains the turbine database in conjunction with component analysis.

Table 2-1.WindPACT Turbine, Rotor, and Nacelle Specifications

	Units	Turbine Ratings					Notes, References, Assumptions
	kW	750	1500	2500	3500	5000	
Calculated Rating	kW	864	1505	2497	3456	4976	Back calculated from rotor diameter using 0.44 kW/m^2
No. of Turbines	each	50	50	50	50	50	
Facility Capacity	MW	37.5	75	125	175	250	Local 115kV line can handle up to 150MW per WAPA survey
Rotor							
Diameter (D)	m	50	66	85	100	120	Selected rotor diameter, back calculated turbine power using 0.44 kW/m^2
Swept Area	m^2	1963	3421	5675	7854	11310	
No. of Blades	each	3	3	3	3	3	Assumes 3-bladed, upwind rotor configuration.
Hub Height	m	65	86	111	130	156	Used ratio of tower height/rotor diameter of 1.3 per SOW.
Rotor Mass	kg	12635	30819	58061	88727	142783	No. of blades x blade mass + hub mass
Solidity	-	0.05	0.05	0.05	0.05	0.05	Assumed typical for 3-bladed rotors.
Projected Area	m^2	98	171	284	393	565	Calculated based on assumed solidity.
Hub							
H x Dia.	m	2.25 x 2.25	3.2 x 3.8	3.8 x 4	3.8 x 4	4.2 x 4.5	
Mass	kg	3816	12516	22457	34136	54604	Hub mass for 2.5 MW+ turbines based on Hub Mass Graph. $m = 0.24D^{2.5765}$
Blade (each)							
Length	m	24.5	32.3	41.7	49.0	58.8	Assumes 2.0% of blade length is comprised of the hub.
Maximum Chord	m	2.5	3.3	4.3	5.0	6.0	Value based on 5% of rotor daimeter.
Maximum Diameter	m	1.35	1.78	2.29	2.70	3.23	5.5% of blade length
Mass	kg	2940	6101	11868	18197	29393	EWEA document. Figure 4.5.2 $m = 0.1D^{2.63}$
Nacelle							
Overall L x W x H	m	6 x 3 x 3	9 x 3.5 x 3.5	10 x 4 x 4	12 x 4 x 4	15 x 4.5 x 4.5	
Total Nacelle Mass	kg	31081	60517	111065	164049	254102	EWEA document. Figure 4.6.3 $m = 2.60D^{2.4}$
Rated Nacelle Mass	kg/kW	41	40	44	47	51	
Empty Nacelle Mass		23311	46173	85839	127575	199170	
Gearbox Mass	kg	4662	9078	16660	24607	38115	Estimated as 15% of Nacelle mass
Generator Mass	kg	3108	5267	8567	11867	16817	Estimated at 10% of Nacelle mass
Tower Head Mass							
Mass	kg	45428	91747	174091	262708	416815	NREL and TVP Turbines Head Mass Graph, $m = 2.2692(D^{2.5318})$
Rated Mass	kg/kW	61	61	70	75	83	
Specific Mass	kg/m^2	23	27	31	33	37	

Table 2-2.WindPACT Tubular Steel Tower Specifications

	Units	Turbines					Notes, References, Assumptions
	kW	750	1500	2500	3500	5000	
Tower							
Number of Sections	each	3	4	5	6	7	
Tower Mass	kg	59,511	136,789	292,035	475,359	821,092	GEC Tower Mass $m = 0.4802D^{2.9978}$
Section 1 (Base)							
Length	m	21.7	21.5	22.1	21.7	22.3	
Base Diameter	m	3.7	4.9	6.4	7.5	9.0	GEC Tower Base Diameter (mm) = 74.708D+5.6748
Diameter 2	m	3.1	4.3	5.7	6.9	8.3	
Mass	kg	28,642	51,574	90,403	124,764	187,016	
Section 2							
Length	m	21.7	21.5	22.1	21.7	22.3	
Diameter 1	m	3.1	4.3	5.7	6.9	8.3	
Diameter 2	m	2.5	3.7	5.1	6.2	7.7	
Mass	kg	19,199	38,757	72,389	104,022	160,349	
Section 3							
Length	m	21.7	21.5	22.1	21.7	22.3	
Diameter 1	m	2.5	3.7	5.1	6.2	7.7	
Diameter 2	m	1.9	3.1	4.4	5.6	7.0	GEC Tower Top Diameter (mm) = 37.354D+2.8374
Mass	kg	11,646	27,771	56,377	85,166	135,732	
Section 4							
Length	m		21.5	22.1	21.7	22.3	
Diameter 1	m		3.1	4.4	5.6	7.0	
Diameter 2	m		2.5	3.8	5.0	6.4	GEC Tower Top Diameter (mm) = 37.354D+2.8374
Mass	kg		18,615	42,366	68,196	113,167	
Section 5							
Length	m			22.1	21.7	22.3	
Diameter 1	m			3.8	5.0	6.4	
Diameter 2	m			3.2	4.4	5.8	GEC Tower Top Diameter (mm) = 37.354D+2.8374
Mass	kg			30,357	53,111	92,653	
Section 6							
Length	m				21.7	22.3	
Diameter 1	m				4.4	5.8	
Diameter 2	m				3.7	5.1	GEC Tower Top Diameter (mm) = 37.354D+2.8374
Mass	kg				39,912	74,191	
Section 7							
Length	m					22.3	
Diameter 1	m					5.1	
Diameter 2	m					4.5	GEC Tower Top Diameter (mm) = 37.354D+2.8374
Mass	kg					57,780	

When evaluating the results of this study, a good understanding of the turbine specifications, dimensions, and masses - and how these may differ slightly from existing machines - is required in order to conduct proper comparisons.

2.1.1 Rotor and Turbine Rating

Because the rotor diameter has the largest single influence on the design and scale of a turbine and most component scaling equations are a function of the rotor diameter, GEC (working with NREL) elected to specify the rotor dimensions and calculate all other dimensions based on published equations or those derived from the turbine database. The rotor diameters selected were 50 m (164 ft), 66 m (217 ft), 85 m (279 ft), 100 m (328 ft), and 120 m (394 ft). An assumed ratio between swept area and rated power of 0.44 was used to calculate the rated power for each turbine. This ratio was derived from the average of the ratio values contained in the turbine database. Applying this ratio resulted in power ratings for the WindPACT turbines of 864,1505, 2497, 3456, and 4976 kW, respectively. For discussion purposes, we classified these turbines as 750, 1500, 2500, 3500, and 5000 kW.

Because the power to swept area ratio of 0.44 was derived from a megawatt-scale turbine database, it produced an overrated turbine at the 50-m rotor diameter scale (864 kW). In general, machines less than a megawatt have had power to swept area ratios between 0.36 and 0.4. Using the 0.44 relationship, a 47-m. diameter rotor would result in a turbine rating of 763 kW, which is closer to the "750-kW" turbine; however, the difference in component dimensions and masses between a 47-m and 50-m. diameter rotor as calculated with the various scaling equations, was negligible from a logistics perspective. Where costs per kW are presented in this report, the calculated turbine power (864, 1505, 2497, 3456, and 4976 kW) is utilized.

Hub height was fixed across each turbine by the hub height to rotor diameter ratio of 1.3. Current design practices use ratios between 1 and 1.3. A relatively high ratio was assumed due to the intended land-based installation, the developing industry sense that wind shear may be higher than previously believed, and the desire to examine the upper limits of component scaling. The 1.3 ratio resulted in the 1500-kW turbine (66-m rotor diameter) having a hub height of 86 m (282.2 ft). Currently, 65-m (213.3 ft) and 80-m (262.5 ft) hub heights are typical for this class of turbine. Although the 1500-kW WindPACT turbine breaks from common practice in this regard, it pushes the scaling limits, and use of the 1.3 ratio resulted in identification of breakpoints associated with the transportation and crane logistics. The latter two issues are discussed further in Sections 3 and 4, respectively.

A rotor solidity value of 5% of the swept area for the three-bladed rotor was selected to facilitate calculation of rotor thrust as part of determining the tower dimensions and masses. This percentage was selected as an average value based on manufacturer information compiled in Technical Area 1 (Blade Scaling) and Figure 5.2 (from Cost Modeling of Horizontal Axis Wind Turbines [1]).

2.1.2 Blades

Assuming that the blades are composed of glass-reinforced fiber, the blade mass was estimated based on the following mass equation [2]:

$$m = 0.1D^{2.63} \qquad \textbf{Equation 2.1}$$

In Figure 2-1, we presented a comparison of this equation to the blade-scaling results of GEC's WindPACT Technical Area 1 study. Recent commercial blade-mass data indicate that actual masses are about 20% less than shown in Equation 2.1; however, this trend does not appear to vary as the blade length increases. Because we determined blade mass to be insignificant in comparison to the physical dimensions, using the above blade mass equation (that overestimates blade mass) does not raise any logistical issues

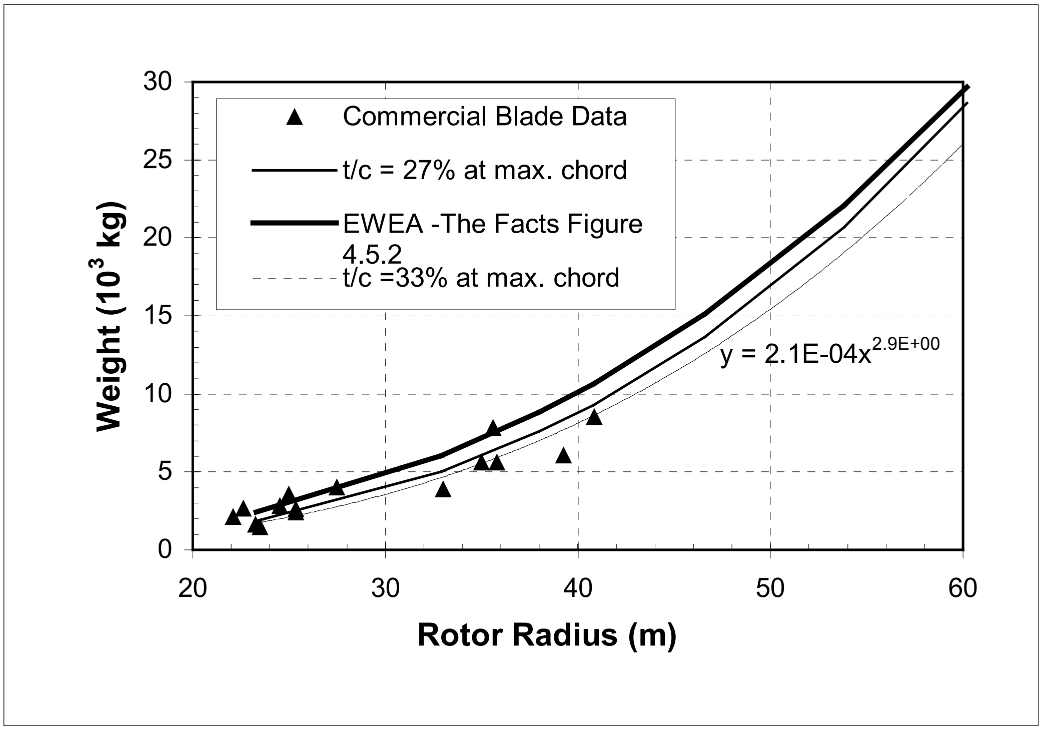


Figure 2-1.Comparison of blade mass equations
(see Appendix A, page 10)

We determined blade dimensions (length, chord, and maximum diameter) were as a function of either rotor diameter or rotor radius (depending on the parameter). The percentage ratios used were based on typical values determined during the blade analysis conducted by GEC as part of Technical Area 1 – Blade Scaling Study.

2.1.3 Hubs

We estimated hub masses using relationships developed from a group of existing turbines for which relatively accurate mass values were known. Blade masses and rotor masses were analyzed to calculate the remaining hub mass. We assumed that the hub mass values used included pitch bearings and the pitch mechanism.

The hub generally is not a component that is prominently discussed in manufacturer literature and its scaling with rotor size does not command much discussion in research literature. The mass-estimating approach used by GEC (see Appendix A page 8) resulted in a hub-mass scaling relationship of:

$$m = 0.24D^{2.58}$$ **Equation 2.2**

We estimated hub dimensions based on their current proportions to blade and nacelle dimensions.

2.1.4 Nacelle

The nacelle masses we presented in Table 2-1 were estimated based on the following scaling formula [2]. The resulting mass does not include the rotor mass.

$$m = 2.6D^{2.4} \qquad \textbf{Equation 2.3}$$

The corresponding nacelle mass associated with the 2500-kW turbine (85-m rotor diameter) exceeded the ability to transport the nacelle over the road via high-capacity tractor trailers, which conflicted with past transport experience with the 2-megawatt Boeing MOD 2 (and more recently, the Nordex N80/2500 turbines). More detailed analysis of nacelle mass was performed by compiling manufacturer mass data and plotting it with respect to rotor diameter. A power fit trend line was applied to the corresponding data point, along with the line added that was associated with the EWEA equation, resulting in Figure 2-2.

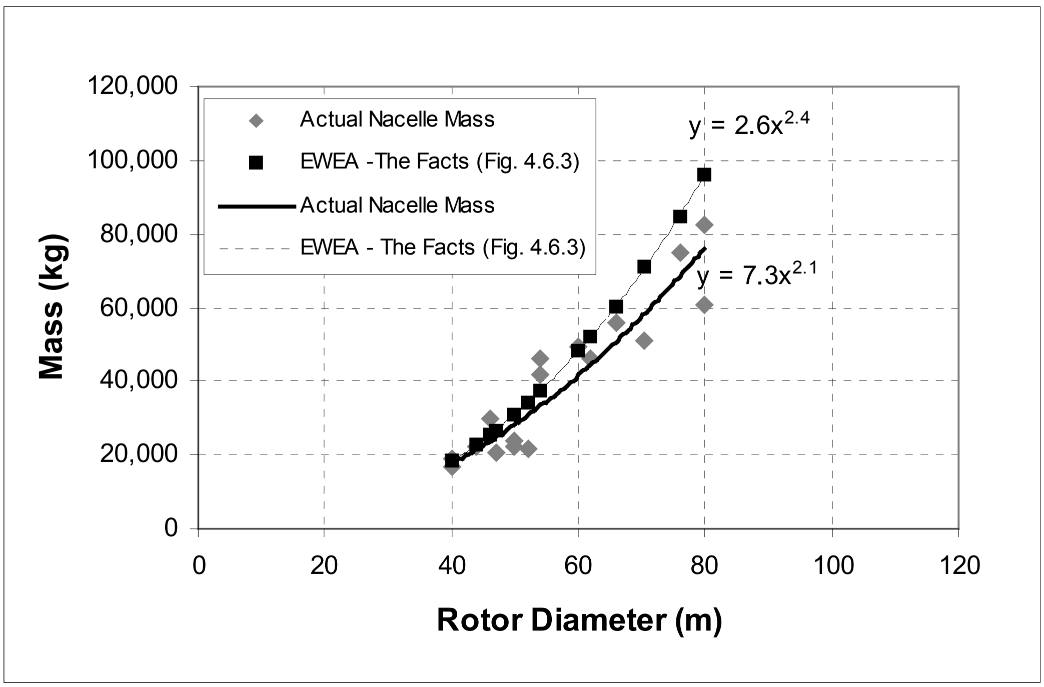


Figure 2-2.Comparison of nacelle mass equations
(see Appendix A, Page 7)

The recent manufacturer data indicate that nacelle masses are not following the trend Equation 2.3. It appears that the manufacturers have been integrating mass-reducing techniques into their nacelle designs, resulting in lighter nacelles. The manufacturer data indicate that the nacelle masses are following an equation closer to:

$$m = 7.3D^{2.11} \qquad \textbf{Equation 2.4}$$

Application of the nacelle mass equation based on recent manufacturer data is important for the 2500-kW (85-m rotor diameter) WindPACT turbine because it results in a nacelle mass of 86,000 kg (190,000 lbs), which is virtually the upper limit of high-capacity tractor-trailer transport capability. Because nacelles at this power rating have been and are being transported by trailers, we decided to use this value when evaluating logistics. Application of Equation 2.3

results in a nacelle mass of 111,000 kg (245,000 lbs) for the 2500-kW turbine (85-m rotor diameter), which is significantly greater than the tractor-trailer capacity limit and would require the use of steerable dollies (which is not current practice). The use of either nacelle mass equation for the 3500-kW and 5000-kW turbines does not affect this logistics study because both yield nacelle mass values that exceed tractor-trailer capacity.

The nacelle contents are assumed to be comparable to those of current generation of turbines. Nacelle dimensions were estimated using existing turbine designs as the basis. Previously, past 2500-kW and 5000-kW research turbines were evaluated to obtain scaling reference points.

For purposes of evaluating alternative assembly, crane, and transportation scenarios, we performed estimates of the gearbox and generator masses. GEC used published data on gearbox and generator scaling relationships [1] to estimate component masses as percentages of the total nacelle mass. The component masses are shown in Table 2-1.

2.1.5 Tower Head Mass

Tower head mass was estimated based on a compilation of specific tower head masses (kg/m^2) and rotor diameters [7]. Additional turbine data from the Turbine Verification Program and new data from the current generation of megawatt-sized turbines were added to the original data. We then converted the data into total tower head mass as a function of rotor diameter, and applied a power fit trend line to obtain the following formula:

$$m = 2.3D^{2.5}$$ **Equation 2.5**

We compared the results from this equation with those from published equations to evaluate its validity. First, we calculated the combined results from Equations 2.1 through 2.3. Another perspective on tower head mass was derived from a combination of recent manufacturer blade, hub, and nacelle mass data. The results are presented in Figure 2-3. The recent manufacturer information yields a lower tower head mass, primarily because the nacelle mass (as calculated by Equation 2.4) is lower.

Component mass is more critical to this logistics study than combined tower head mass; however, evaluation of the equations used to estimate head mass is important to confirm the validity of the values being presented. Tower head mass has been calculated for comparison purposes but does not enter into the analysis of logistics. Based on this analysis, the tower head mass in Table 2-1 appears to be greater than recent manufacturer data may be indicating. The difference in nacelle discussed in Section 2.1.4 is the largest contributor to the differences in tower head mass.

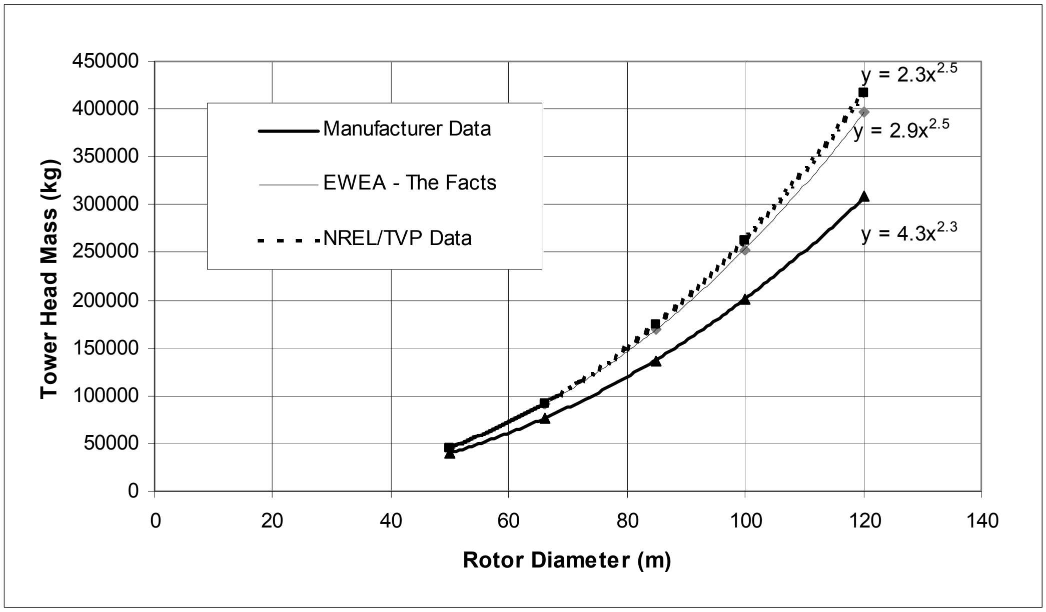


Figure 2-3.Comparison of tower head mass equations
(See Appendix A, Page 4)

2.1.6 Towers

It was assumed that the current design of tapered tubular steel towers would be used for all WindPACT turbines, resulting in the use of the following assumptions and design criteria.

An International Electrotechnical Commission (IEC) class 2 wind regime was assumed for the tower design based on the previously stated wind resource information associated with the area of interest in South Dakota. The analysis generally followed the IEC design approach to calculate rotor thrust, tower drag, and total overturning moments. Application of material assumptions, hub height to rotor diameter assumptions, tower wall thickness to diameter assumptions, and use of load and material factors resulted in calculation of tower diameters and total mass. We assumed a linear tower taper for simplicity. Finally, we derived total characteristic base moments exclusive of the load factor to obtain values applicable to the design of the tower foundation in Technical Area 4 (Balance of Station Costs).

We used a peak-load scenario to design the towers; however, we made certain deviations from IEC protocol to account for fatigue and dynamics. We also assumed the peak-loading scenario would occur during a pitch control system failure with the blades in an operating position. IEC allows the use of the Ve1 wind speed [44.5 m/s (99.5 mph) for class 2 along with possible modification of the load factor] under this fault scenario; however, GEC elected to use the Ve50 wind speed value 59.5 m/s (133.1 mph) in addition to the load and material factors. This returns a conservative design for the peak-load condition. However, if an actual design was performed, it is likely that fatigue and/or dynamics would determine the tower shape and size. Based on a preliminary evaluation, we determined that fatigue would likely dictate tower sizes similar to those resulting from the modified peak load scenario being used.

Logistically, the critical results of this design process were the total tower mass, base diameter, and tower top diameter. Incorporating this information with hub height and analysis of typical tower section lengths being used resulted in an estimate of the number of tower sections per turbine class and the corresponding diameters. We calculated tower section masses by determining the steel volume for each section based on the dimensions then multiplying by the steel density. Non-structural steel mass was excluded from the total mass calculated by GEC.

Figure 2-4 presents a comparison of the GEC-calculated tower mass to recently manufactured towers for which relatively accurate mass information was known. The manufacturer data contain a rather high degree of scatter, which indicates different design approaches. In general, the GEC calculations appear to be underestimating tower mass by about 20%. Because a modified peak-load approach to calculating the loads on the tower is being used, it is possible that actual tower designs are being driven by fatigue and dynamics, resulting in higher masses. A comparison of manufacturer's tower diameter data to those calculated by GEC's model is presented in Table 2-3. This table indicates that the model results are within an acceptable range of variation that could be expected. The calculation spreadsheet is in Appendix A.

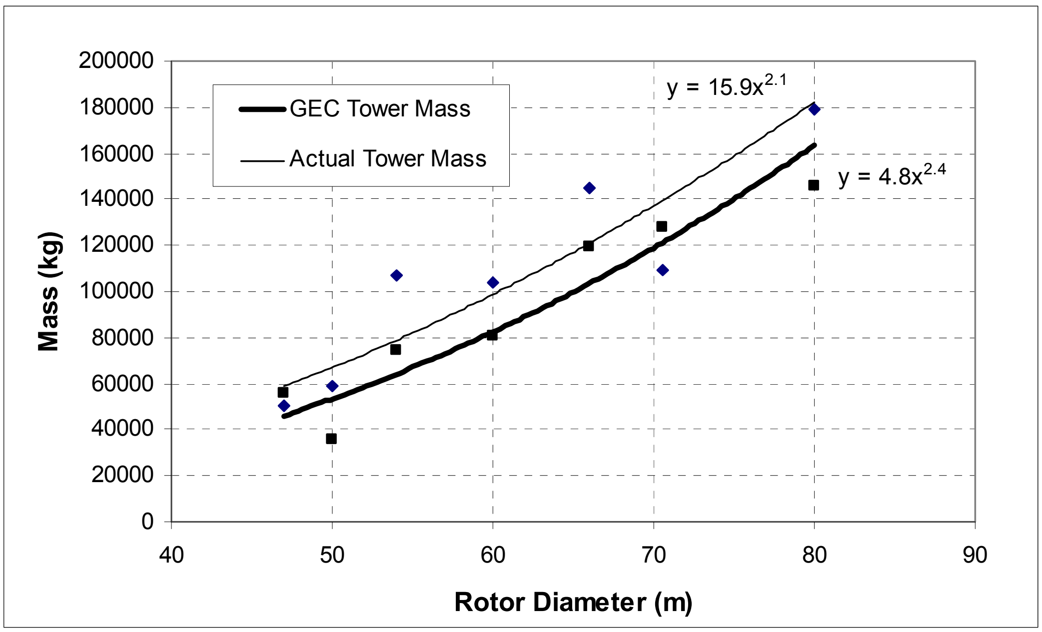


Figure 2-4.Comparison of tower masses
(see Appendix A, Page 6)

Table 2-3.Comparison of Manufacturer Tower Data with GEC Calculations

Turbine		Manufacturer Data			GEC Tower Calculations		
		Total	Tower Diameters		Total	Tower Diameters	
		Tower Mass	Base	Top	Tower Mass	Base	Top
Vestas	V66	145,000 kg	4.3 m	2.3 m	120,000 kg	4.8 m	2.4 m
		320,000 lbs	14.1 ft	7.5 ft	263,000 lbs	15.75 ft	7.9 ft
Vestas	V47	50,700 kg	4.0 m	2.1 m	56,000 kg	3.6 m	1.8 m
		112,000 lbs	13.1 ft	6.9 ft	123,000 lbs	11.8 ft	5.9 ft
Zond	Z-750	59,000 kg	3.7 m	2.7 m	35,600 kg	3.3 m	1.7 m
		130,000 lbs	12.1 ft	8.9 ft	78,500 lbs	10.8 ft	5.6 ft

2.2 Organization of Study

After determining the sizes and masses of the various turbine components we provided, the specifications to GEC's transportation, assembly, and crane consultants for analysis, determination of logistics, and costing. GEC developed three basic scenarios to identify specific breakpoints in the turbine specifications and costs. The scenarios were also developed to determine the impact of implementing measures not currently used by the wind energy industry to alleviate critical logistic issues that arose due to increased turbine scale. The three scenarios are described as follows:

- Scenario 1: This is the baseline scenario in which the current practices associated with component transportation, turbine assembly, and crane utilization are used for each WindPACT turbine without modification for increased turbine scale. Specifically, turbine components are transported and assembled in as few pieces as possible, relying upon the efficiency of preassembly to the maximum extent possible. This scenario also represents minimal field assembly and assumed that the rotors are preassembled on the ground before being placed onto the nacelle.

- Scenario 2: Scenario 2 deviates from Scenario 1 in two critical aspects. First, tower sections that present specific logistical issues due to their dimensions and/or masses are quartered lengthwise and therefore require on-site assembly. Three on-site assembly approaches were then developed and analyzed. Second, rotor assembly was assumed to be performed with the nacelle and hub installed onto the tower.

- Scenario 3: Scenario 3 corresponds to Scenario 2 except that the gearbox and generator are handled as individual components exclusive of the nacelle. This case represents the maximum on-site assembly requirements and a significant increase in the number of objects that require handling. For simplicity, the on-site tower assembly approach that appeared most practical under Scenario 2 was retained as the tower assembly approach for Scenario 3. Therefore, the impact of multiple nacelle components could be isolated.

Further clarification and assumptions used within each of these scenarios as they relate to transportation, assembly, and cranes are presented in the following sections.

Table 2-4.Summary of Logistic Scenarios

Logistic Scenarios	Description
Scenario 1	Current transport and assembly techniques applied to all turbine sizes without modification.
Scenario 2	Field-fabricate quartered tower sections, blades assembled to hub in the air.
Scenario 3	Same as Scenario 2, plus gearbox and generators are handled as individual components exclusive of the nacelle.

3. Transportation Logistics

3.1 Background

We evaluated logistics for various modes of transportation and included multi-modal options when required. The transportation modes evaluated were tractor-trailer, rail, steerable-dolly, barge, and chartered ocean/Great Lakes vessels. Currently, transportation of wind turbine components within the United States is generally performed with the use of trucks and, to a lesser extent, rail.

Road Access
The hypothetical project site in south-central South Dakota can only be accessed via local roads within a 80 to 95 km (50 to 60 mi) radius. U.S. Highway 18 is the primary east/west road in the area. U.S. Highways 83 and 183 are the primary north/south roads that connect U.S. 18 to Interstate 90.

Railroad Access
The Burlington Northern-Santa Fe (BNSF) railroad operates a short track line called the Dakota & Southern Railroad that parallels Interstate 90 from Mitchell, South Dakota, to Kadoka, South Dakota. BNSF has exclusive operating rights within North and South Dakota and northern Nebraska. Maps of the Union Pacific Railroad and Burlington Northern Railroad networks are shown in Figures 3-1 and 3-2, respectively.

Union Pacific Railroad Service Units

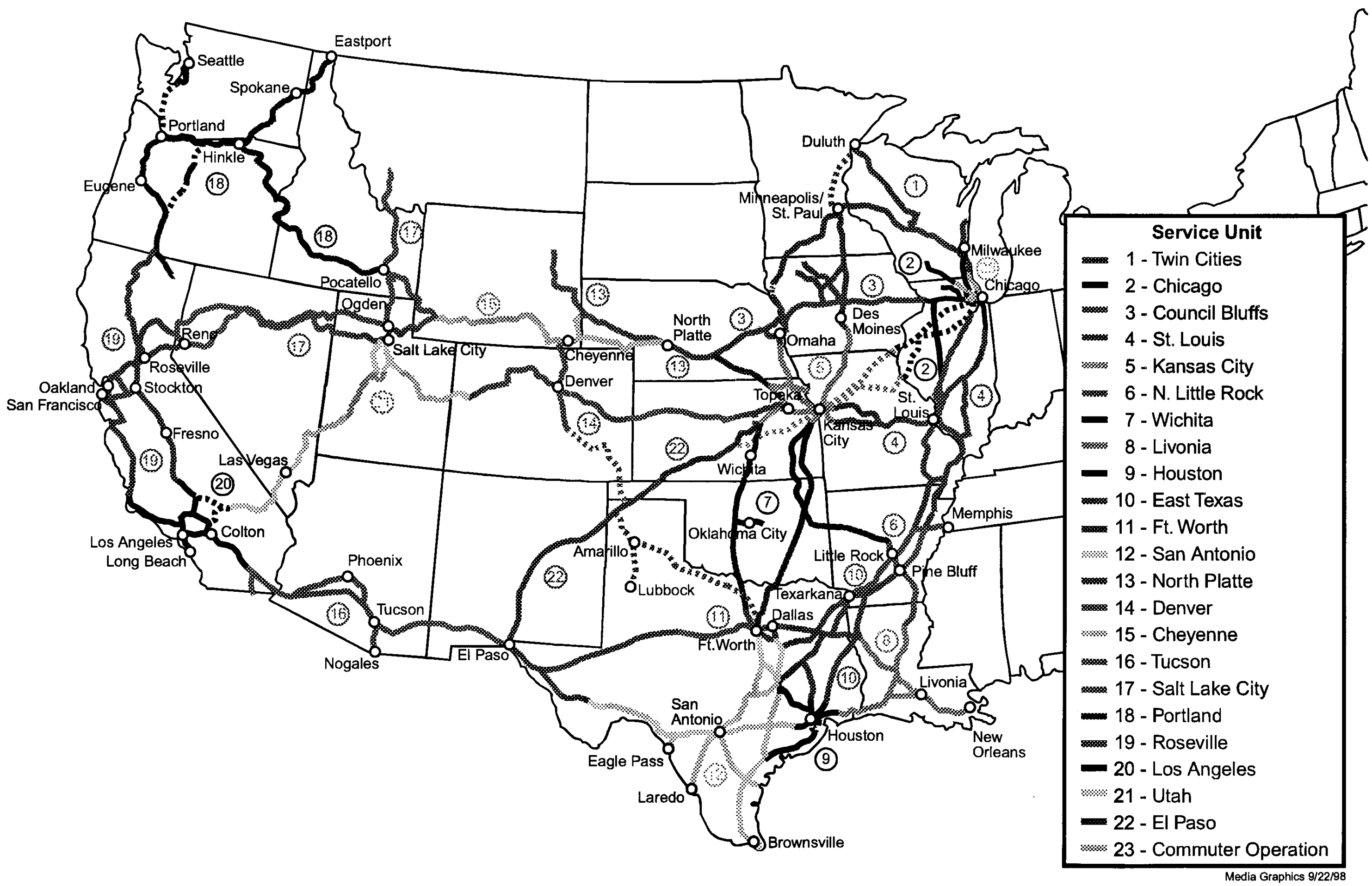


Figure 3-1.Union Pacific Railroad network

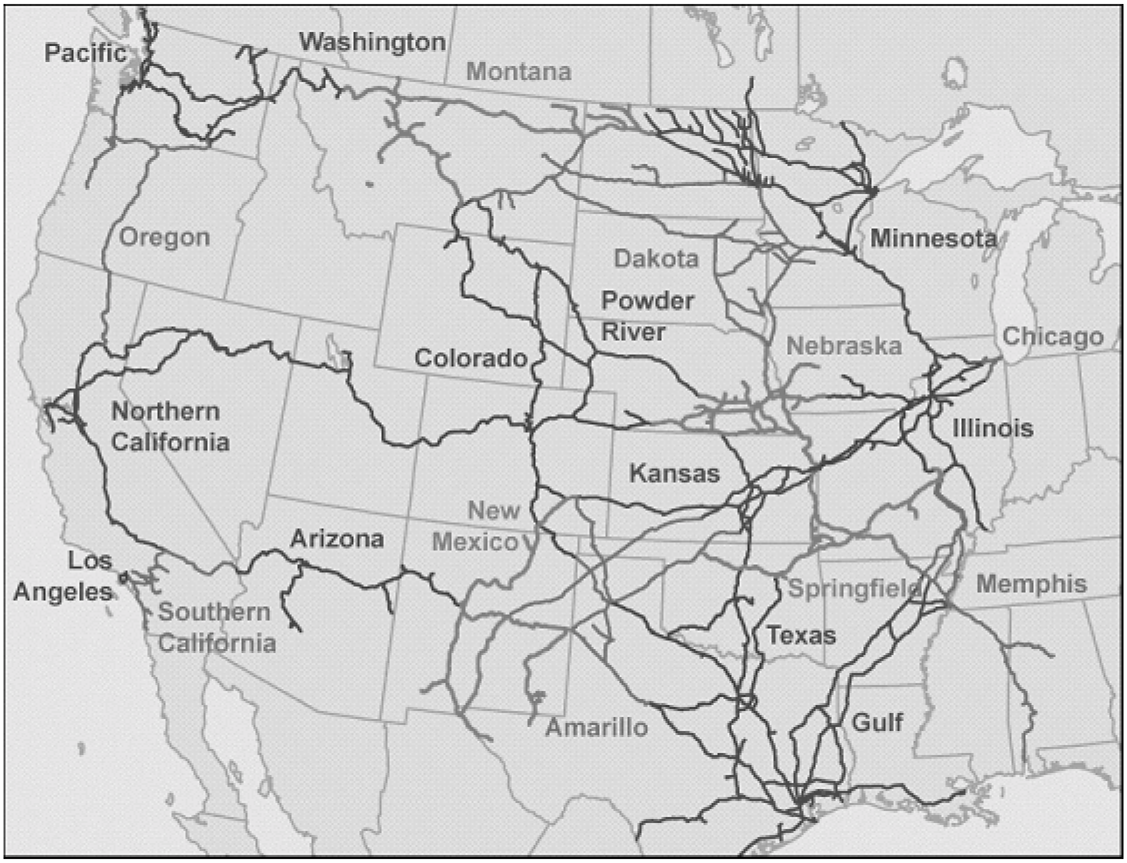


Figure 3-2.Burlington Northern-Santa Fe Railroad network

Figure 3-3 shows a more detailed view of the Dakota & Southern Railroad area. Potentially viable debarkation towns are Presho, Murdo, and Kennebec, South Dakota. These towns are within 80 to 95 km (50 to 60 mi.) of the assumed project site. This area of South Dakota is significantly closer to rail lines than most favorable wind sites in the upper Midwest. Considering the remoteness of the hypothetical project site, access to a rail spur relatively close to the site is beneficial.

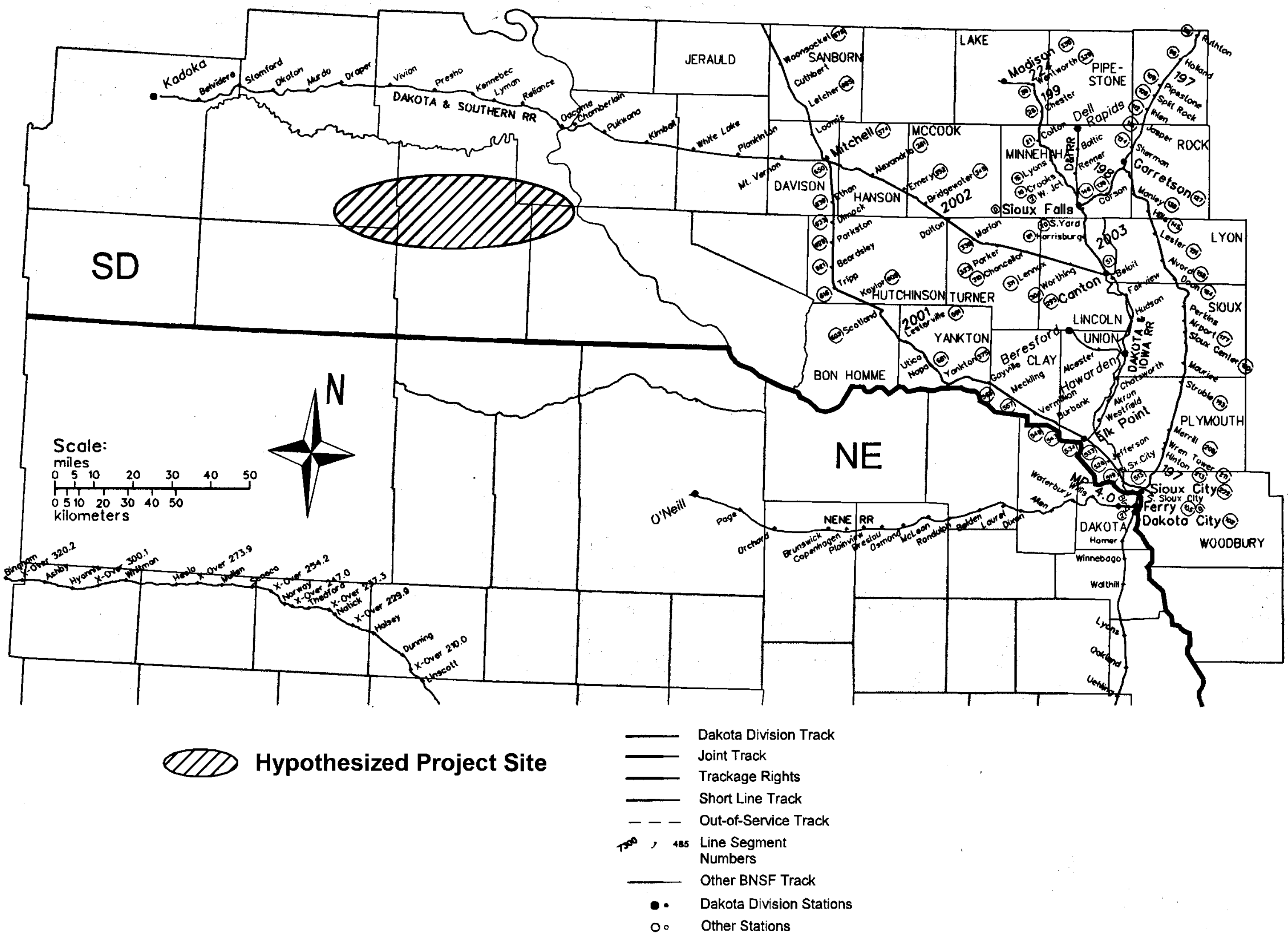


Figure 3-3.Dakota & Southern Railroad

Water Access
Water access is possible by deck barge on the Missouri River up to Sioux City, Iowa. Beyond Sioux City, the Missouri River is not specifically maintained for navigation. A series of six-flood-control and power-generating dams begin near Yankton, South Dakota, that inhibit navigation up river. The Omaha District of the U.S. Army Corps of Engineers (USACE) was contacted to assess the potential for navigation between Sioux City, Iowa, and Yankton, South Dakota. The USACE stated that the Missouri River is free flowing between Yankton and Sioux City and no that navigation channel is maintained. Therefore, use of barge transport is not possible beyond Sioux City, Iowa.

The normal navigation season on the Missouri River is 8 months; however, there are specific dates that affect operations. The navigation season at Sioux City, Iowa, opens on March 23, however, access from the mouth near St. Louis, Missouri, is not possible until April 1. The season at Sioux City, Iowa closes on November 22 and on December 1 at the mouth near St. Louis. Therefore, the effective period in which wind turbine components can be delivered to Sioux City, Iowa, is between April 1 and November 22.

The next closest navigable waterway to the project site is through the Great Lakes (specifically at the Port of Duluth, Minnesota). Although primarily a bulk-commodity port, the piers have handled "project cargo" movements in the past where delivery to larger more popular ports along the lakes proved unfeasible.

3.2 Transportation Assumptions

We assessed transportation logistics associated with wind turbine components delivered into South Dakota for three basic travel distances: short haul, long haul, and overseas. Short hauls encompassed an area with a radius around the project site of approximately 600 to 700 miles and included areas such as Chicago, Illinois; Green Bay, Wisconsin; and Duluth, Minnesota; Sioux City, Iowa; and Denver, Colorado. Long-haul transportation distances were considered anything greater than the short-haul radius. Over short-haul distances the use of steerable dollies in addition to tractor-trailers is feasible, allowing an increase in the weight that can be transported over the road. Dollies however, are not feasible over long distances or through multiple states. Long hauls incorporated the use of all possible modes. We also evaluated ocean shipping for components manufactured in Europe assuming that chartered ships equipped with cargo cranes would be used to deliver turbine components to the ports of either Houston or Duluth.

Based on experience with oversized and overweight transportation, ATS noted that Nebraska, Kansas, and to a lesser extent Missouri and Iowa, can be difficult states to pass through with excessive loads. Being situated in the middle of the country results in a tremendous amount of transportation activity in these states and places a large (and possibly disproportional) burden on their infrastructure. In addition, because these states tend to be more agricultural as opposed to industrial areas such as the Great Lakes or Gulf Coast, their transportation regulations have evolved to be more accommodating to agriculture rather than heavy industry. Although it is not impossible to transport oversized and overweight loads through these states, it generally requires more effort and greater planning costs to obtain the necessary permits and approvals. Additional expenses incurred by traveling around these states are less than what would be spent obtaining permission to pass through. Recognizing these factors, ATS selected travel routes through Texas, Oklahoma, Missouri, Iowa, North Dakota, Illinois, and Minnesota.

Based on their experience, ATS selected the following routes to develop estimated transportation costs for the listed components. In addition to maximizing the likelihood of permit approval, these routes were based on understanding the current source areas for existing turbine components.

Blades
L-M Glasfiber in Grand Forks, North Dakota, and Molded Fiber Glass, Inc. (MFG), in Gainesville, Texas, were used to estimate short-haul and long haul costs, respectively. Costs for blade transport from Europe were based on delivery to the ports of Duluth and Houston. Viable transport modes were chartered ocean ships, trucks, steerable dollies, and barges.

Hubs
Hubs were supplied from Chicago, Illinois for short-haul-estimating purposes and from Tehachapi, California, for long-haul-estimating purposes. In addition, transport costs from the ports of Houston and Duluth were generated to estimate costs for European-supplied components. Viable transport modes include chartered ocean ships, trucks, and rail.

Nacelles
Costs estimates for transport of nacelles used the same points of origin as the hubs. However, modifications to the routes were required due to the need for steerable dollies and barges. Viable transport modes include chartered ocean ships, trucks, rail, steerable dollies, and barges.

Towers
Three primary suppliers of tubular steel towers are based in Canutillo, Texas (near El Paso), Dallas, Texas, and Shreveport, Louisiana; therefore, tower transport costs were calculated from these areas. Although highly unlikely, tower transport costs from Europe were estimated for comparison purposes. Viable transport modes include trucks, steerable dollies, barges, and chartered ocean ships

3.3 Oversized Load Permits

In the United States the transportation regulation system has unique rules, regulations, and oversized permit requirements for each state. This system requires transporters such as ATS to research and determine the lowest common denominator with respect to the type of shipment being planned, its origin, and destination. Demonstrating to permit officials that all possible means have been assessed or used to either minimize travel distances, or select appropriate by-pass routes, is critical in obtaining permits. Typically, detailed transportation plans are developed by the transport company that are based on specific object sizes, weights, origin, destination, and unique handling requirements. Alternative approaches are evaluated, costs are refined, and adjustments to comply with unique state requirements are made resulting in the final transportation plan. To attempt this type of detailed analysis was beyond the scope of the project; however, these plans can reduce costs or even eliminate the need for obtaining oversized permits.

The number of assumed turbines is a significant factor effecting the viability of certain transportation techniques discussed in this study. State officials are generally more accepting of one or a few oversized/overweight transport loads as opposed to 50 or 150 shipments. The long-term disruption of traffic and inconvenience to local populations would be considered intrusive. Technically, stresses placed on the infrastructure by one or a few oversized/overweight loads can be accommodated; however, the cyclical stress of multiple over-dimensioned loads could significantly increase the possibility of failure and is another factor making permits for large numbers of shipments very difficult to obtain.

Based on information from ATS, the 4.9-m (16-ft) loaded height is a point at which transport companies and permitting authorities become concerned about actual or potential load clearance with overhead structures and/or utilities. In addition to height, the shape of the load is also a factor. Rectangular or circular loads have larger profiles as opposed to triangular or vertical loads. It is easier to negotiate triangular or vertical loads around low-hanging objects (street lights for example) without npresenting the need for temporary removal of the utility. Based on ATS's experience, circular loads do not provide this type of flexibility. It is also possible for utilities to temporarily interrupt service on overhead utilities but not drop the line(s) to reduce the potential for injury and equipment damage in the event of an accidental strike.

The 4.9-m (16-ft) overhead utility height constraint is a larger issue in areas with older infrastructure or in rural areas; as opposed to recently built infrastructure. Careful route selection can help avoid such areas, however, it's highly probable that at least one low-utility area will be encountered during shipment. Excessive height causes considerable increases in the transport costs because local utilities are required to temporarily disconnect power, drop and protect the lines, then reinstall the wires in order for the load to pass. Utilities generally charge considerable expenses to perform this work to cover their costs including service disruption and planning costs to "permit fees" thus presenting a considerable deterrent to movement of loads with excessive height. Excessive height moves can effective, however, when all possible alternatives have been evaluated and the number of utility assist areas has been minimized. However, movement of numerous objects (50 to 350 tower sections) in this manner will not be cost effective and will likely not receive permit approval.

To underscore the difference between states, we compared South Dakota and Nebraska legal truck weights. In South Dakota, truckloads up to 70,300 kg (155,000 lbs) using 13 axles are possible without the issuance of a special permit. However, Nebraska's limit is 43,000 kg (95,000 lbs) using 7 axles. Therefore, a legal load in South Dakota requires an overweight permit in Nebraska.

3.4 Equipment Capacity and Limitations

Overweight permits usually are issued with specific dates during which transport is prohibited. These dates are state specific but tend to eliminate periods during the spring when frozen ground is thawing. Over-dimension permits are likely to have travel time limits in congested areas, limiting movement to non-rush-hour periods.

A breakdown of critical vehicle dimensions by transportation mode is presented in Table 3-1. The overall dimensions and weights correspond to the combined vehicle and load. Points at which oversize or overweight permits are required have also been noted. Application of the overall vehicle limitations to the specific wind turbine objects resulted in Table 3-2. Table 3-2 presents the breakpoint dimensions associated with wind turbine components beyond which significant increases in transportation costs occur.

Table 3-1.Overall Dimensions

MODE	EQUIPMENT	OVERALL WIDTH	OVERALL HEIGHT	OVERALL LENGTH	OVERALL WEIGHT (GVW)
Tractor-Trailer Trucks	Standard Trailers	2.6 m (8.5 ft)	4.1 m (13.5 ft)	14.6-16.2 m (48-53 ft)	up to 36,300 kg (80,000 lbs)
	Special Multi-Axle Drop Trailers	2.6 m (8.5 ft)	4.1 m (13.5 ft)	14.6-16.2 m (48-53 ft)	36,300-70,300 kg (80,000-155,000 lbs) (State dependant)
	Special Multi-Axle Drop Trailers w/ OW Permits	2.6 m (8.5 ft)	4.1 m (13.5 ft)	38.1-45.7 m (125-150 ft)	up to 102,100-106,600 kg (225,000-235,000 lbs)
	Special Multi-Axle Drop Trailers w/ OW and OD Permits	6.1-7.6 m (20–25 ft) possible (route dependant)	4.83 m (15.8 ft) triggers utility assistance	38.1-45.7 m (125-150 ft)	up to 102,100-106,600 kg (225,000-235,000 lbs)
Steerable Dolly System	Custom-built system utilizing modular wheel systems	Route dependant	4.83 m (15.8 ft) triggers utility assistance	Route dependant	Route dependant
Rail	Standard Flat 8 Axle Heavy	3.4 m (11 ft)	4.0 m (13 ft) from top of rail	27.4 m (90 ft)	up to 163,300 kg (360,000 lbs)
Barge	Deck Barge	16.5 m (54 ft)	-	76.2 m (250 ft)	217,700-272,200 kg (480,000–600,000 lbs)
Ocean Vessel	Chartered vessel with cargo cranes	-	-	-	-

OW – Overweight
OD – Over-dimensioned

Table 3-2.Breakpoint Dimensions

OBJECT	OBJECT HEIGHT	OBJECT WIDTH	OBJECT LENGTH	OBJECT WEIGHT
Blades	4.4 m (14.5 ft)	7.6 m (25 ft)	45.7-48.8 m (150-160 ft) (transport distance and route dependant)	Not Problematic
Hubs (w/o permits)	3.7 m (12 ft)	Not Problematic	Not Problematic	17,200-19,100 kg (38,000-42,000 lbs)
Nacelles	3.7 m (12 ft)	Not Problematic	Not Problematic	79,400-83,900 kg (175,000-185,000 lbs)
Towers (w/o permits)	3.7 m (12 ft)	-	16.2 m (53 ft)	17,200-19,100 kg (38,000-42,000 lbs)
Towers (w/ permits)	4.4 m (14.5 ft)	-	Not Problematic	79,400-83,900 kg (175,000-185,000 lbs)

3.5 Analysis of Scenarios

3.5.1 Scenario 1

Blades

Blades for 750-kW, 1500-kW, and 2500-kW turbines can be moved with relative ease by truck. Their dimensions and masses are manageable and minimal rerouting would be necessary. Extendable flatbeds that have been modified to carry blades would be the primary technique employed. Combining numerous blades (up to six) into single transport containers (particularly the 750-kW turbine blades), although efficient for ship transport, is illegal in certain states for road transport. According to states' jurisdictions these loads are "reducible," thus requiring the transporter to remove blades from the container before proceeding. This action indicates a wider acceptance and greater likelihood of permit approval for multiple over-dimensioned loads that are within the 36,000-kg (80,000 lb) gross vehicle weight (GVW) limit than fewer over-dimensioned and overweight loads. Therefore for cost estimating purposes, it has been assumed that three 750-kW blades, two 1500-kW blades, and one 2500-kW blade would be transported. These arrangements would stay within the 36,000-kg (80,000-lb) GVW limit, therefore requiring a permit for width and length exceptions only. For this study, we assumed that three 750-kW blades (oriented root to tip with the leading edges perpendicular to the ground) would result in a standard load dimension of 2.6 m (8.5 ft) in width by 4.1 m (13.5 ft) in height. Two 1500-kW blades (oriented root to tip with the leading edges parallel to the ground) would result in the oversized load dimensions of 3.3 m (10.8 ft) in width by 3.9 m (12.8 ft) in height. It was assumed that individual 2500 kW and larger blades would be placed on a transport trailer with their leading edges parallel to the ground. Transport costs per kW for the 750 kW to 2500 kW blades ranged from $2.91 to $7.14, depending on turbine size and origin. Transportation costs per mile ranged from $4.74 to $5.50.

Blades for the 3500-kW turbine can be transported over the road, however they will require a different approach. Objects with lengths exceeding approximately 45 m (150 ft) require the use of rear-steering equipment in addition to the prime mover. The blade dimensions and corresponding transport equipment will likely incur up to 25% additional miles between the shipping origin and destination due to rerouting. To reduce the overall height, it has been assumed that the blades are placed with the leading edge parallel to the ground. This orientation will require adequate support of the blade from the mid-section to the tip where bending will be the greatest. These factors increased the transport costs to between $5.51 and $11.56 per kW. The costs per mile for moving the 3500 kW blades were estimated to be $9.50.

The 5000 kW blade and transport equipment will exceed the 36,000 kg (80,000 lb) GVW requiring the use of special multi-axle equipment. The total vehicle length of over 200 feet will likely cause permit difficulties for long haul scenarios since approval from multiple States would be necessary (increasing the possibility of denial), therefore this blade will only be able to travel on roads over short haul distances. In instances such as this, state official would rather see efforts put into mitigating road travel through the use of water travel. By demonstrating all reasonable efforts are being utilized to minimize land travel, acceptance and permit approval potential increases. A long haul cost scenario was estimated assuming the 5000 kW blades originated in Gainesville, Texas and were driven onto a deck barge at the Port of Houston. Given space limitations on the deck barge only two blades and corresponding trucks (assuming one blade per truck) could be accommodated on the barge. From the Port of Houston the barge would travel through the Mississippi and Missouri River Systems to Sioux City, Iowa. The blade/truck combinations would then be driven north through Iowa and South Dakota to the project site. The resulting road transport costs of $11.00 per mile reflect the increased complexity of associated with moving these blades. The associated road transport costs for these blades range from $2.19 to $7.29 per kW. However, the barge component of this scenario contributes $96.56 per kW. A 5000 kW blade manufactured in Texas would need to be transported to the Port of Houston and driven onto a deck barge. Upon arrival in Sioux City, Iowa, the vehicle would be driven off the barge and delivered to the project site. The total costs for this movement was estimated to be $100 per kW. Although the use of barges facilitates movement of these large blades over great distances, their dimensions adversely impact the costs since it is been estimated that only two blade/truck combinations per barge could be accommodated.

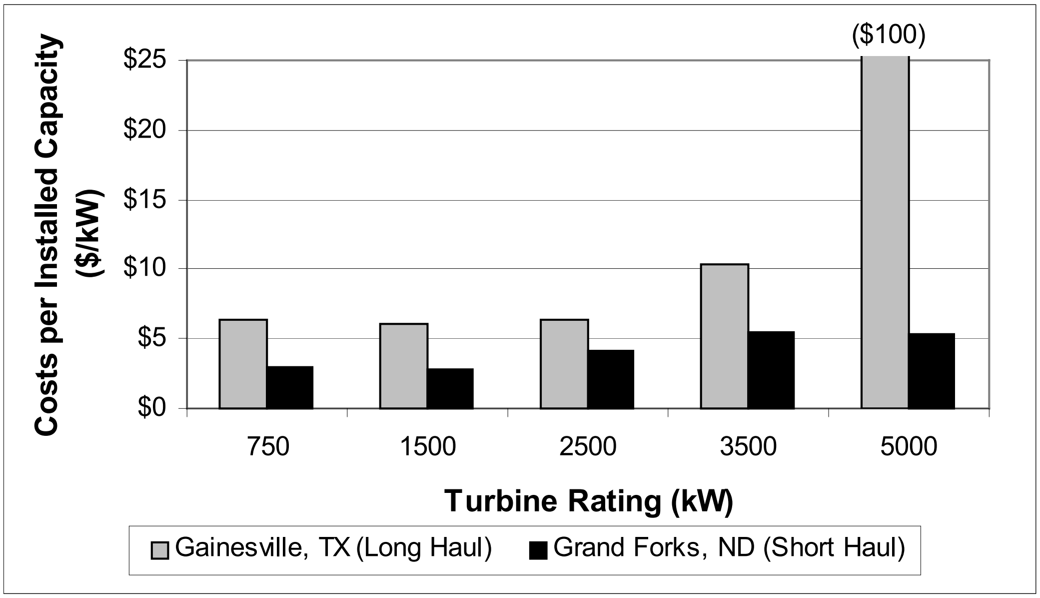


Figure 3-4.Estimated blade transport costs
(See Appendix P, Page 1)

Figure 3-4 presents truck transportation costs associated with blades manufactured in Texas and North Dakota. As would be expected, the costs from North Dakota are lower, particularly for the 5000 kW turbine. The largest reduction in costs is associated with not incurring barge costs from Houston, Texas to Sioux City, Iowa.

Hubs

Transportation of hubs does not appear to pose difficulty for any of the turbines. As the dimensions and masses increase they stay within a range that is easily accommodated by truck and rail transport. The hub transport costs per turbine increase as could be expected with turbine size, however, a peak in the transport costs per kW occurs at the 1500 kW turbine due a change in the transport trailer equipment. A trailer change is necessitated by the combined hub mass and vehicle mass exceeding 36,000 kg (80,000 lbs). This slight transport inefficiency for the 1500 kW turbine has minimal impact to the total transportation costs since hub transport costs are insignificant in comparison to the other components.

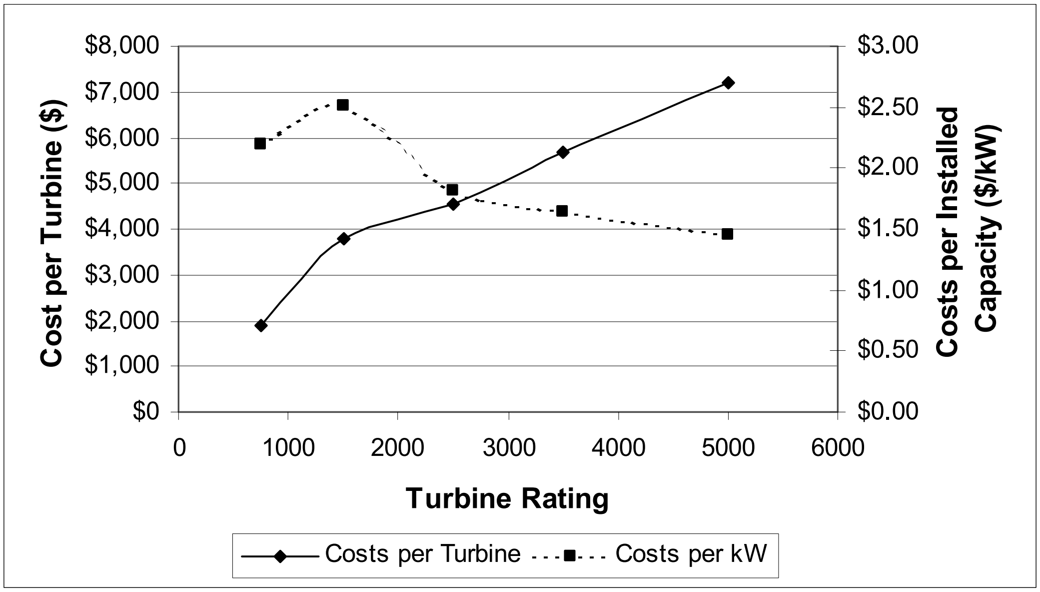


Figure 3-5.Hub transportation costs from Chicago, Illinois
(See Appendix P, Page 2)

Nacelles
Transport of 750 kW, 1500 kW, and, 2500 kW nacelles can be accommodated by truck and rail with truck transport being more cost effective primarily because it does not incur a mode transfer expense. Costs to transport the 750 kW to 2500 kW nacelles via truck were estimated to range from $2.64 to $7.32 per installed kW. The same costs for rail transport (including offload and final truck/dolly delivery costs) ranged from $6.07 to $15.44. Truck and rail costs are generally very comparable provided the rail destination is close to the project site, resulting in minimal additional road transportation costs.

Steerable dollies and rail can accommodate the 3500 kW nacelle. However, dolly and rail costs are very different over both short haul and long haul scenarios with rail costs being significantly lower. Dolly costs for this turbine was about $70 per kW where as the rail costs (that include an offloading crane and the appropriate transport from the rail spur to the project site) were about $20 per kW. Based on the proximity of a rail spur within 80 km (50 mi) of the project site, rail has been determined to be the best option for the 3500 kW nacelle transport.

Rail transport adds an element of risk related to nacelle damage during transit. Sudden accelerations and decelerations during start-up and braking, train coupling and decoupling, rail joints, and less sophisticated rail car suspensions can induce sufficient forces and vibrations to result in damage or misalignment of components. Accelerometers are typically placed on delicate loads to monitor shipping loads.

A comparison of nacelle transport costs by mode originating from Chicago, Illinois is presented in Figure 3-6. The cost trends from Tehachapi, California are similar and differ in magnitude only. Dolly costs for the 2500 kW are presented to demonstrate the increase in shipping costs if the 2500 kW nacelle exceeds 84,000 kg (185,000 lbs).

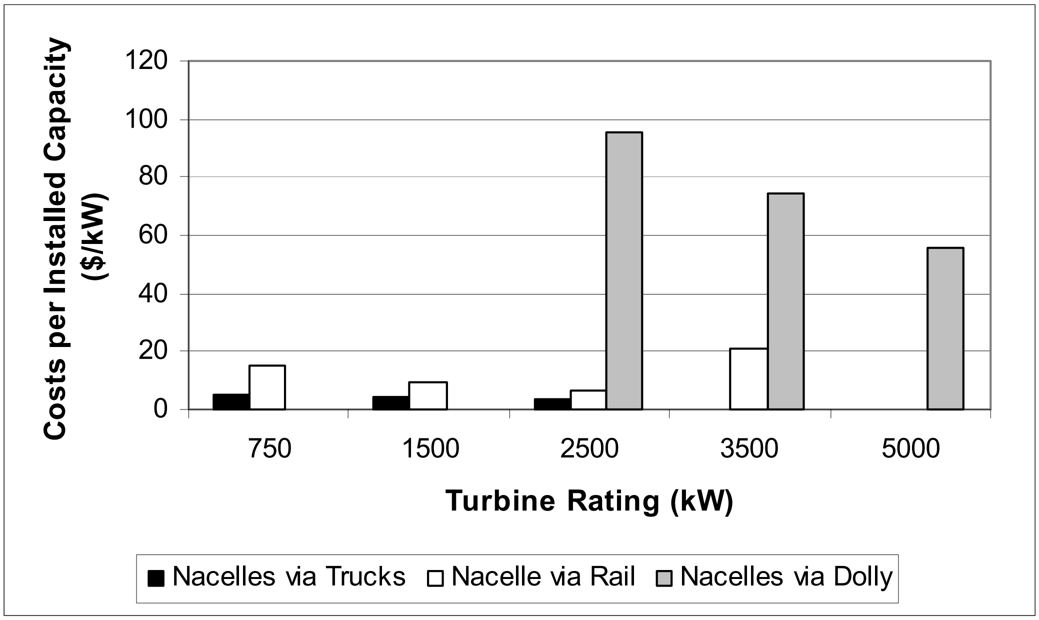


Figure 3-6.Comparison of nacelle transport modes from Chicago, Illinois (short haul)
(See Appendix P, Page 3)

The mass of the 5000 kW nacelle results in steerable dollies being the only short haul option available. Long haul movement would require the combined use of dollies and barges because the nacelle exceeds the rail capacity of 163,000 kg (360,000 lbs). Short haul dolly costs for the 5000 kW turbine ranged from \$50 to \$90 per kW depending upon the distance. For long hauls the additional barge costs was estimated to be \$45 per kW. In general, as the turbine sizes increased the dolly costs per kW decreased with the highest dolly costs being incurred for the 2,500 kW turbines.

The 163,000 kg (360,000 lb) limitation for rail transport of the nacelle dictates that the target turbine transportable by rail would have a 100-m (328-ft) rotor diameter corresponding to the 3500 kW turbine.

Tower

Transport of intact tubular tower sections will rely upon trucks, steerable dollies, and barges. An unexpected result of the tower dimensions and specifications utilized in this study was that the base section of the 1500 kW turbine could not be transported cost effectively by truck or dolly. This is in stark contrast to current practice in which 750 and 1500 kW towers are being moved over the road in a relatively cost effective manner. The 1500 kW WindPACT turbine tower stands 86 m (282 ft) high with an estimated base diameter of 4.9 m (16 ft). The current 1500 kW turbines are on towers up to 80 m (262 ft) high and utilize base diameters of about 4.3 to 4.4 m (14.1 to 14.3 ft). The base diameter of the WindPACT tower results in a total vehicle height exceeding 4.83m (15.83 ft) which exceeds the height at which utility assistance is triggered resulting is extreme costs and planning logistics.

Costs to move the intact base section of the 1500 kW tower with a base diameter of 4.9 m (16 ft) from the Texas/Louisiana area to South Dakota were based on dolly transport to the Port of Houston (\$125 per kW, see Appendix E, page 4), barge transport to Sioux City, Iowa (\$44 per kW, see Appendix G, page 4), then dolly transport to South Dakota (\$107 per kW, see Appendix

E, page 4). A direct land route was not evaluated since obtaining the necessary permits and organizing all of the utilities along the route would prove to be infeasible and State authorities would likely state that a "reasonable by-pass" utilizing the Mississippi and Missouri rivers is present and should be utilized. Using this approach, the costs to transport the 1500 kW base section alone was estimated to be $276 per kW while the total for the remaining sections was estimated at $19.50 per kW. The total tower transport costs for the 1500 kW turbine with a base diameter of 4.9 m (16 ft) was $295 per kW.

If the base diameter of the 1500 kW turbine was 4.4 m or less (eliminating the need for utility assistance and barge travel), the estimated transport costs for the base section alone was $8.12 per kW with a resulting total turbine tower shipping cost of $27 per kW. Since existing tower designs for 1500 kW turbines employ base diameters of about 4.3 to 4.4 m (14.1 to 14.3 ft), the excessive tower shipping costs associated with a base diameter of 4.9 m (16 ft) are not being utilized further in this report. Instead, we are assuming that the base diameter of the 1500 kW turbine is less than 4.4 m (14.3 ft) and can be shipped without the need for utility assistance or barge transport. Tower designers can keep the base dimensions less than 4.4 m using a variety of options such as modifying the tower wall thickness to diameter ratio or adjusting the taper ratio.

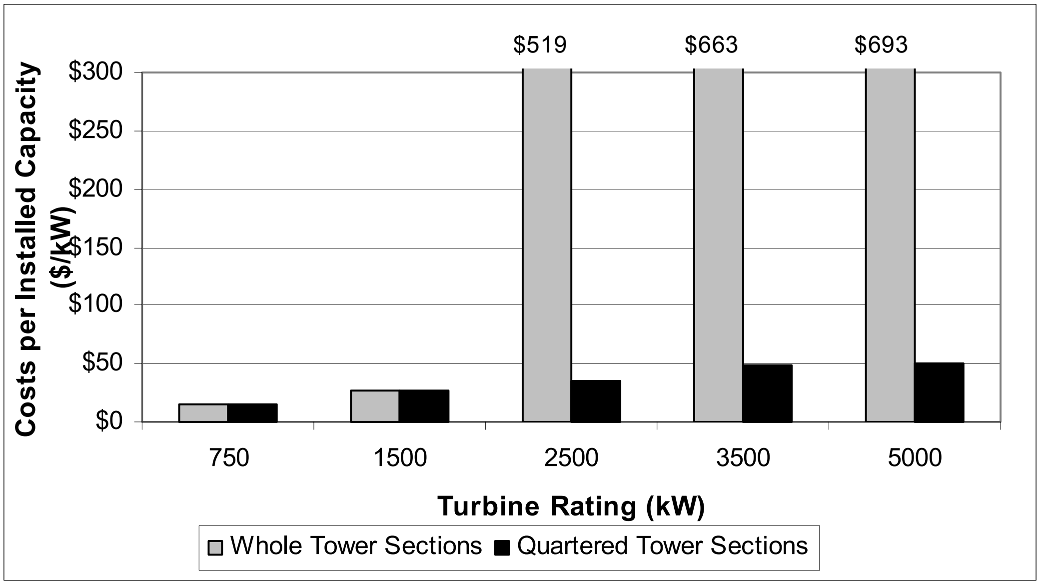
3.5.2 Scenario 2

Towers

From a transportation perspective, the only impact of Scenario 2 is to mitigate tower transportation issues and costs. Under this scenario, it has been assumed that oversized tower sections are quartered lengthwise. This results in tower pieces that are dimensionally compliant with the height restrictions discussed above and in many cases results in a gross vehicle weight at or less than 36,000 kg (80,000 lbs). All transports are within the 79,400 to 83,900 kg (175,000 to 185,000 lbs) range eliminating the need for high capacity dollies. It was assumed that only one quartered tower piece would be transported on a trailer to help improve permit approval potential and eliminate the possibility of a "reducible load" ruling.

This approach had a significant impact on the transportation costs. All of the tower sections and pieces could be transported for costs ranging from $1.40 to $11.00 per mile. For those loads that exceeded 36,000 kg (80,000 lb) GVW the costs per mile range from $6.00 to $11.00, demonstrating that a significant costs savings can be realized by keeping vehicle weight under 36,000 kg (80,000 lbs). Total tower short haul costs per kW ranged from about $16 for the 750 kW turbines to about $51 for the 5000 kW turbines. These same costs per kW under Scenario 1 were about $16 and $692, respectively. Figure 3-7 presents a comparison of the estimated tower transportation costs by scenario for tower sections originating from Louisiana. The significant increase in the number of loads required to deliver all of the tower pieces was more than offset by incurring lower transport costs per mile.

Section 4 of this report discusses the assembly costs in further detail, however, the additional costs incurred to assemble the tower sections were minor in comparison to the transportation costs savings.



TURBINE RATING (KW)	750	1500	2500	3500	5000
Scenario 1	$16	$27	$519	$663	$693
Scenario 2	$16	$27	$35	$48	$51

Figure 3-7.Scenario 1 and Scenario 2 tower transportation cost comparisons
Costs based on transport from Shreveport, Louisiana (see Appendix P, page 4)

3.5.3 Scenario 3

Nacelle
The third scenario in which the primary nacelle components (gearbox and generator) are removed and shipped to the site separately only had a beneficial impact on costs associated with transporting the 5000 kW nacelle. Under Scenario 3, the generators can be shipped on typical flat bed trailers within the 80,000 GVW limitations to take advantage of low cost per mile rates (about $1.50). It was estimated that the mass of the gearbox for the 3500 and 5000 kW turbines would require the use of double-drop type trailers resulting in cost per mile rates of about $11.

Shipping costs for the 2500 kW and 3500 kW nacelles actually increased slightly due to requiring three shipments per nacelle as opposed to only one. A sufficient mass reduction for the 3500 kW and 5000 kW 'empty nacelles' was not realized to allow the use of tractor-trailers instead of rail or dollies. Rail costs for the nacelles remained virtually unchanged between Scenario 2 and 3. The 5000 kW still could not be moved by rail leaving dollies the only transport option for this nacelle. Under this scenario, truck transport was determined to be the preferred nacelle transport mode for nacelles up to 2500 kW. The 3500 kW nacelle would likely be transported by rail and the 5000 kW nacelle would still need to be transported by dolly.

Analysis of the rail transport costs reveals a very slight decrease in the rail costs however when the truck transport costs for the generator and gearbox components are included, the total costs increase slightly. Rail shipping rates are based on the object weight and decrease as the object mass increases. Table 3-3 demonstrates the rail cost reduction with weight increase. Therefore, more favorable rail economics are realized when the nacelles shipped by rail remain intact.

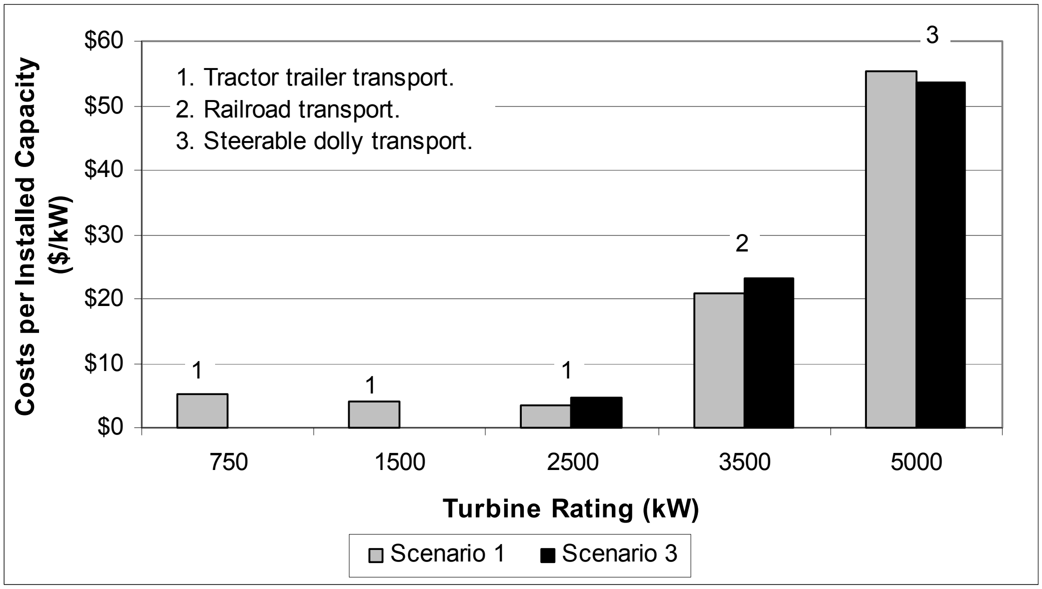


Figure 3-8.Comparison of nacelle transport approaches
Costs include truck, rail and dolly modes from Chicago, Illinois (see Appendix P, Page 5)

Table 3-3.Example Rail Costs from Houston, Texas

Weight (lbs)	$/100 lbs
Up to 75,000	$3.53
75,000 to 125,000	$3.15
125,000 to 240,000	$2.88
240,000 to 360,000	$2.72

3.6 Emerging Transportation Technology—Airships

Currently, the main use of airships is advertising, however, their attributes combined with new technology and materials are expanding their commercial potential into transportation logistics. The concept is straight forward, eliminate (or significantly reduce) the planning and permitting requirements associated with oversized and overweight loads on land with airship freight that has higher capacity and lower costs than current cargo aircraft. Large, heavy objects like conventional generators, oil refinery components, and wind turbines, which must be shipped to their final destination in pieces by road, rail, and ship, could be transported directly in one piece. Worldwide, a number of companies are actively developing high capacity airships.

Three general approaches to airship design exist, non-rigid (advertising ships), semi-rigid, and rigid (classic Zeppelin design). There are 2 approaches to cargo transport by airship emerging, internal and external payloads. The internal payload approach is aimed at containerized freight and direct competition with ocean transport. External payloads are targeted at both containerized freight and the oversized object market. The external payload approach has also been referred to as a "flying crane" approach.

The furthest-advanced airship companies are Advanced Technologies Group (ATG) and Cargo lifter. ATG has developed a flying radio controlled prototype. Their design is a semi-rigid airship that employs aerodynamic lift in addition to the buoyancy effect of helium. ATG's SkyCat has targeted internal payloads of 15 mt, 200 mt, and 1000 mt (33,000 lbs, 440,000 lbs, and 2,200,000 lbs). Cargo lifter also employs a semi-rigid design, however, its external payload is targeted at 160 mt (350,000 lbs). Cargo lifter has developed a long list of investors and is currently building a manufacturing facility in Brand, Germany. For comparison purposes, the largest cargo aircraft, the Ukrainian Antonov AN-225 has a payload capacity of 250 mt (550,000 bs).

Airship transport costs are being estimated as lower than aircraft cargo but higher than ocean freight. Since airships do not need to consume fuel to stay aloft, a considerable operating expense is minimized. In comparison to ocean freight, the higher velocities of airships could result in quicker transport time. Airship transport costs are targeted in the range of $0.45 to $0.66 per kg. For comparison, aircraft freight ranges from $1 to $10 per kg and ocean freight is approximately $ 0.25 per kg (or per cubic meter, which ever is greater). Current design and manufacturing activity is focused on infrastructure and prototypes. Deployment of the first commercial cargo airships is anticipated in 2003 to 2005.

4. Assembly and Crane Logistics

4.1 Assembly Assumptions

For purposes of this study, turbine assembly was assumed to include:

- Offloading turbine components from transport vehicles, uncrating, sorting, and distribution across the site.
- Rigging and setting the tower sections including bolt inspections.
- Grouting base tower section and torque verification.
- Assembly of the blades and hub into the rotor inclusive of pitch mechanisms and alignment.
- Rigging and setting nacelles onto tower tops including alignment, application of proper bolt torque, and connection of basic electrical equipment.
- Rigging and setting the rotor assembly to the nacelle.
- Installation of climbing equipment, setting controllers, and installing power cables from nacelle to base.
- Crane relocation assistance between turbines.

Construction of the turbine foundations is not included in the turbine assembly estimates. Foundation costs are presented in WindPACT Technical Area 4 – Balance of Station Costs. Turbine commissioning activities are also excluded from the assembly estimates.

Assembly crews were based on 10 to 12 people working six days per week. The crew size was based on typical crew sizes currently being used by construction companies. Considering the remote project site, it was likely that some activities would be performed on Saturday since the work crews would not return home for the weekends. It is likely that Saturday work would be used to help offset less productive weekdays if and when weather impacts the project.

The level of effort required to perform various tasks for the 2500 kW and larger turbines was based on experiences gained during assembly of the current generation of 750 kW and 1500 kW turbines. Efforts were based on object sizes, work heights, assembly techniques, and the type of crane being utilized. The current practice of installing tower base sections with a relatively small capacity truck or rough terrain crane was utilized for each type of turbine. This technique allows assembly activity to be performed during inclement weather when high rotor or nacelle work cannot be performed. It also helps to minimize the time on-site for the high capacity installation crane.

In addition to estimating the levels of effort required for various activities, the ‘general condition costs’ were also prepared. These are construction related costs that are incurred for a variety of items. The primary general condition cost categories include:

- Professional services – consulting engineers and inspectors
- Construction management personnel
- Travel and Relocation expenses
- Field office expenses
- Temporary construction facilities and tool storage
- Mobilization and demobilization transport costs

- Temporary construction utilities
- Construction equipment
- Worker safety
- Final site clean-up
- Project start-up and closeout

The principal general conditions expense is for the construction equipment used for a project. The following equipment was included in development of the construction equipment costs:

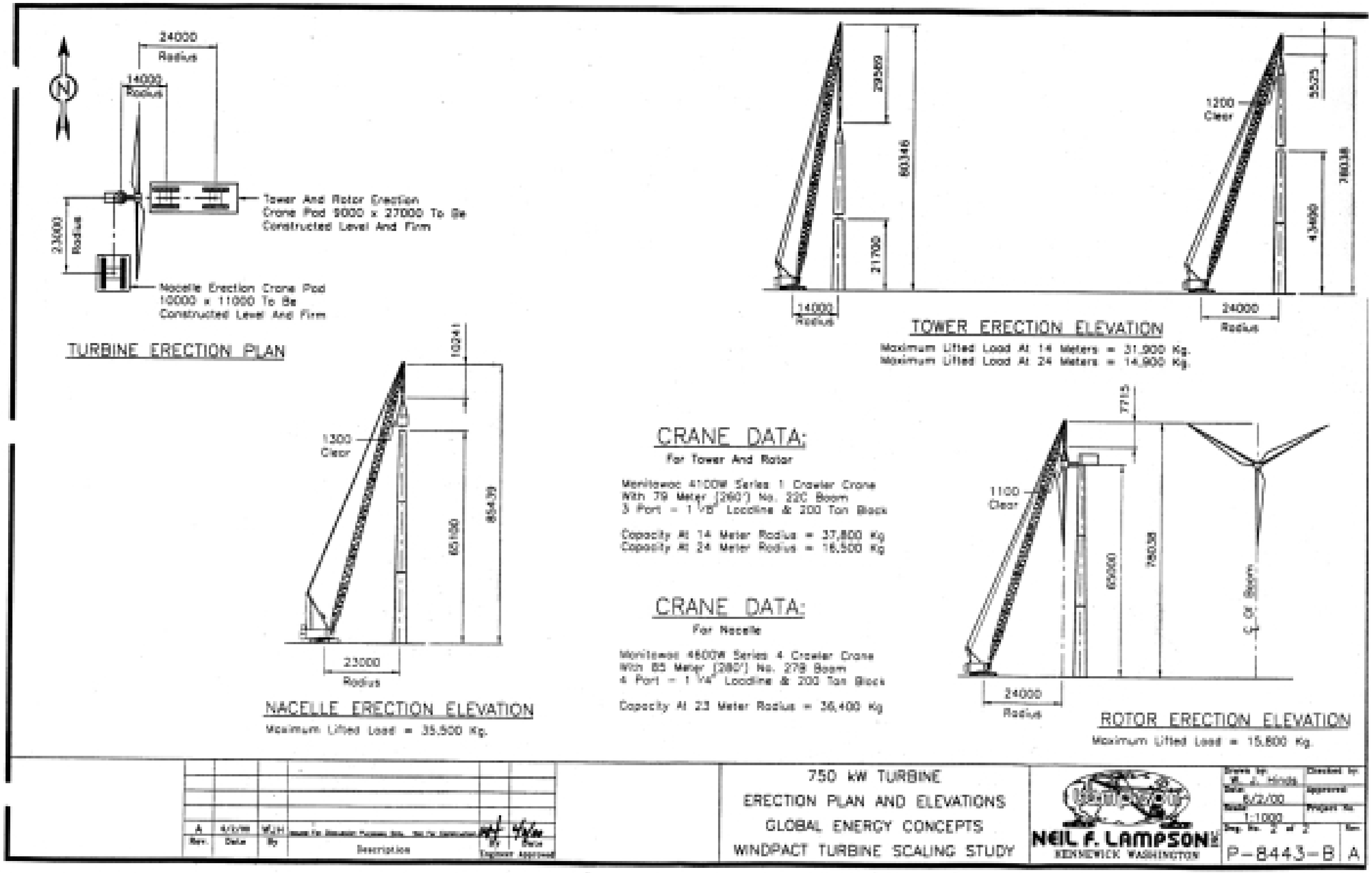
- 2 hydraulic truck cranes (sizes were adjusted for weights of turbine components)
- Crawler crane for offloading freight
- 2 rough terrain forklifts
- Surveying/Level equipment
- Radios/phone communications
- Bolt torque equipment
- Site pick-up trucks
- Equipment fuel and operating expenses
- Equipment repairs
- Small tools/Consumables
- Crane operator and oiler.

Costs presented in this section were based on estimates prepared by the M.A. Mortenson construction company and reflect a conservative approach. Lower costs can be realized if site conditions and weather are ideal, however, practical experience has demonstrated that these conditions cannot be relied upon.

4.2 Crane Assumptions

The turbine specifications presented in Table 2-1 and Table 2-2 were provided to Lampson for analysis and selection of the most cost effective crane options. Given the specified hub heights and component masses, a specific crane was selected for each turbine. Lampson prepared the drawings shown in Figures 4-1 through 4-5 to help illustrate crane setup requirements, lifting position, clearances, crane pad space requirements, and scale. Once the crane type, counter-balance mass, boom length, and jib length (if required) were selected numerous costs were estimated and have been summarized in Appendix B. Items included in the costs are monthly rental rates, stand-by rates, crew size, crane transport, crane assembly requirements, crane relocation rates (between turbines), and consumables.

Figure 4-1.750-kW crane
(Measurement units: mm)



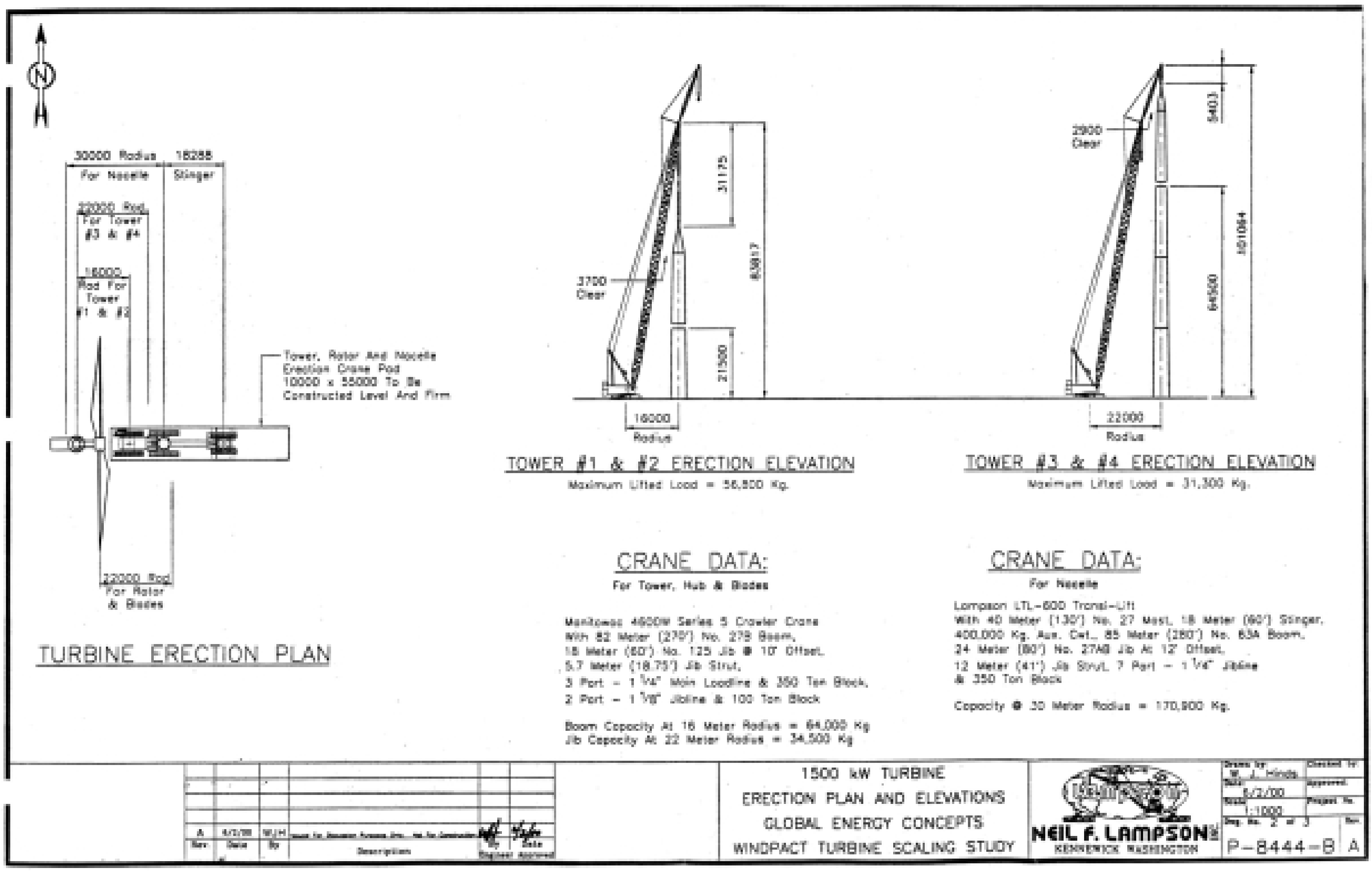


Figure 4-2.1500 kW crane
(Measurement units: mm)

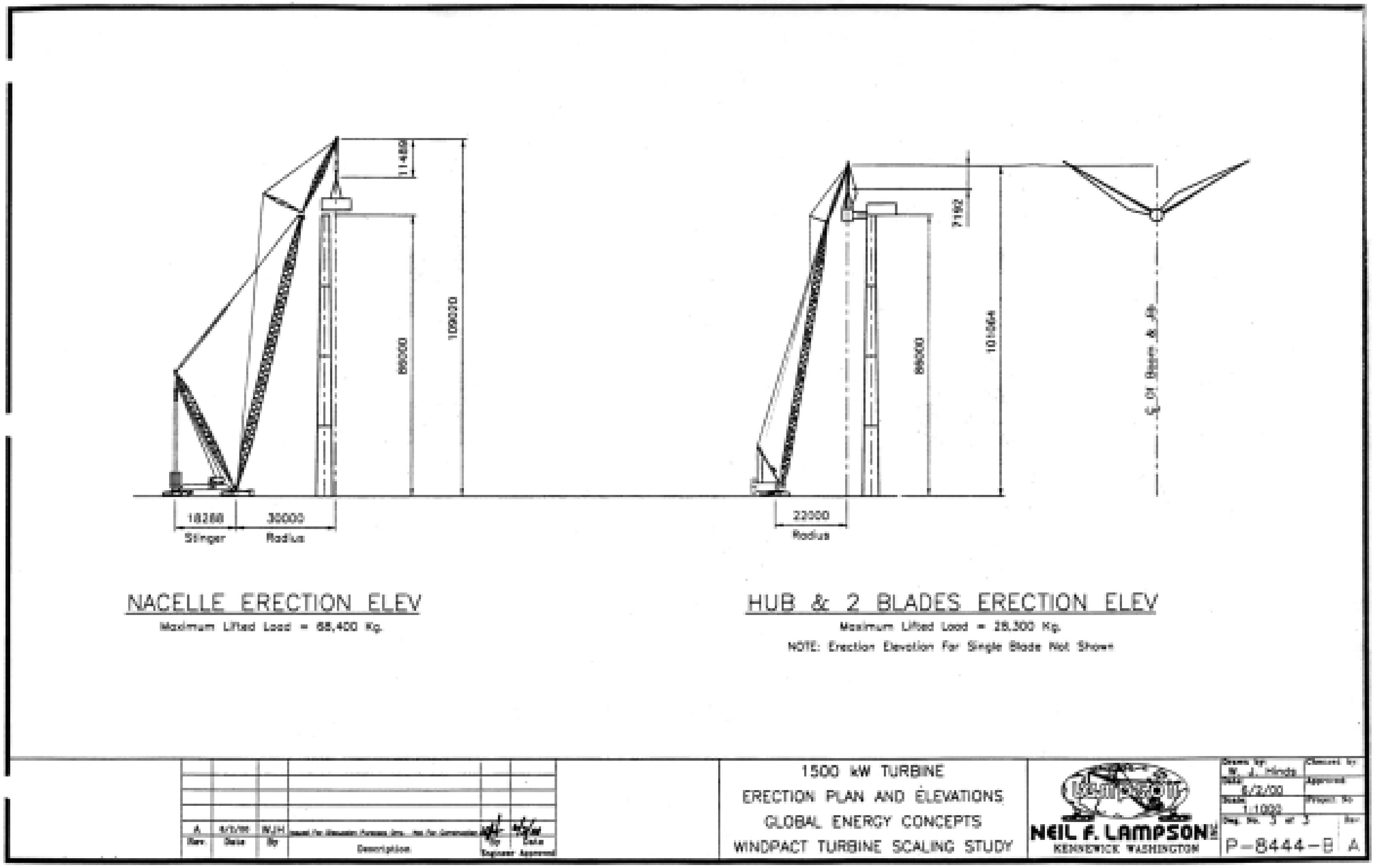


Figure 4-2.1500-kW crane (Continued)
(Measurement units: mm)

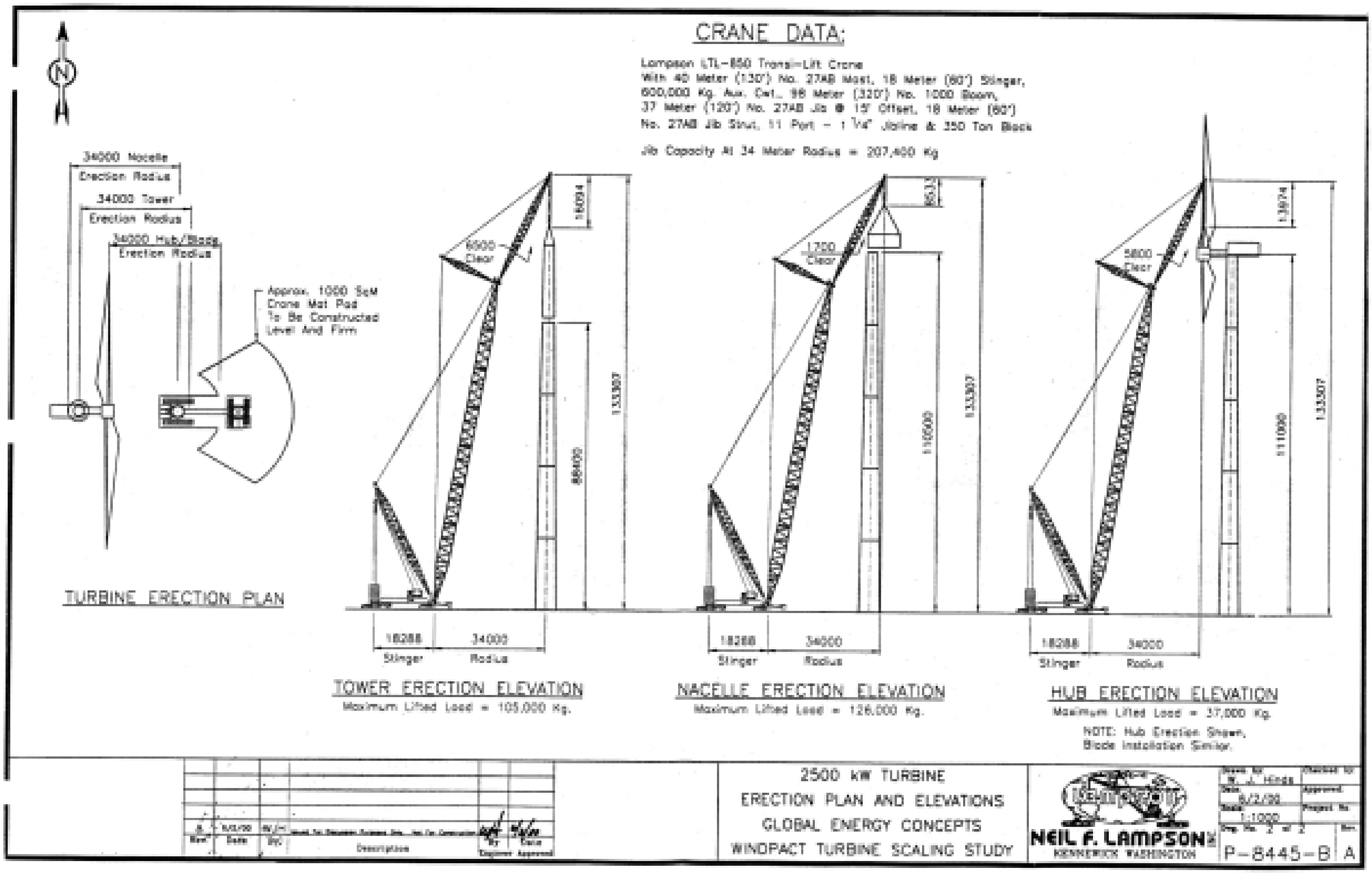


Figure 4-3.2500-kW crane
(Measurement units: mm)

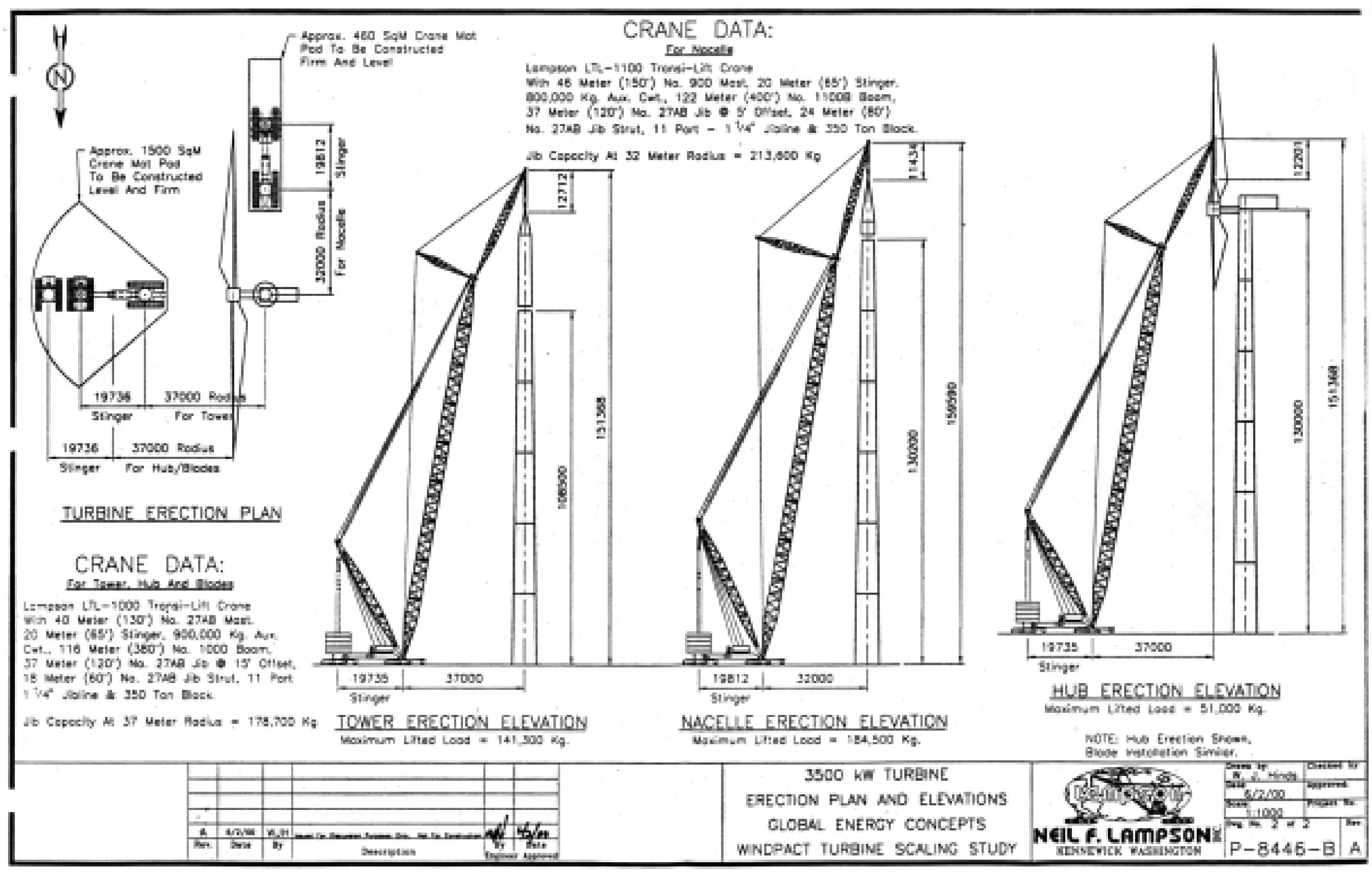
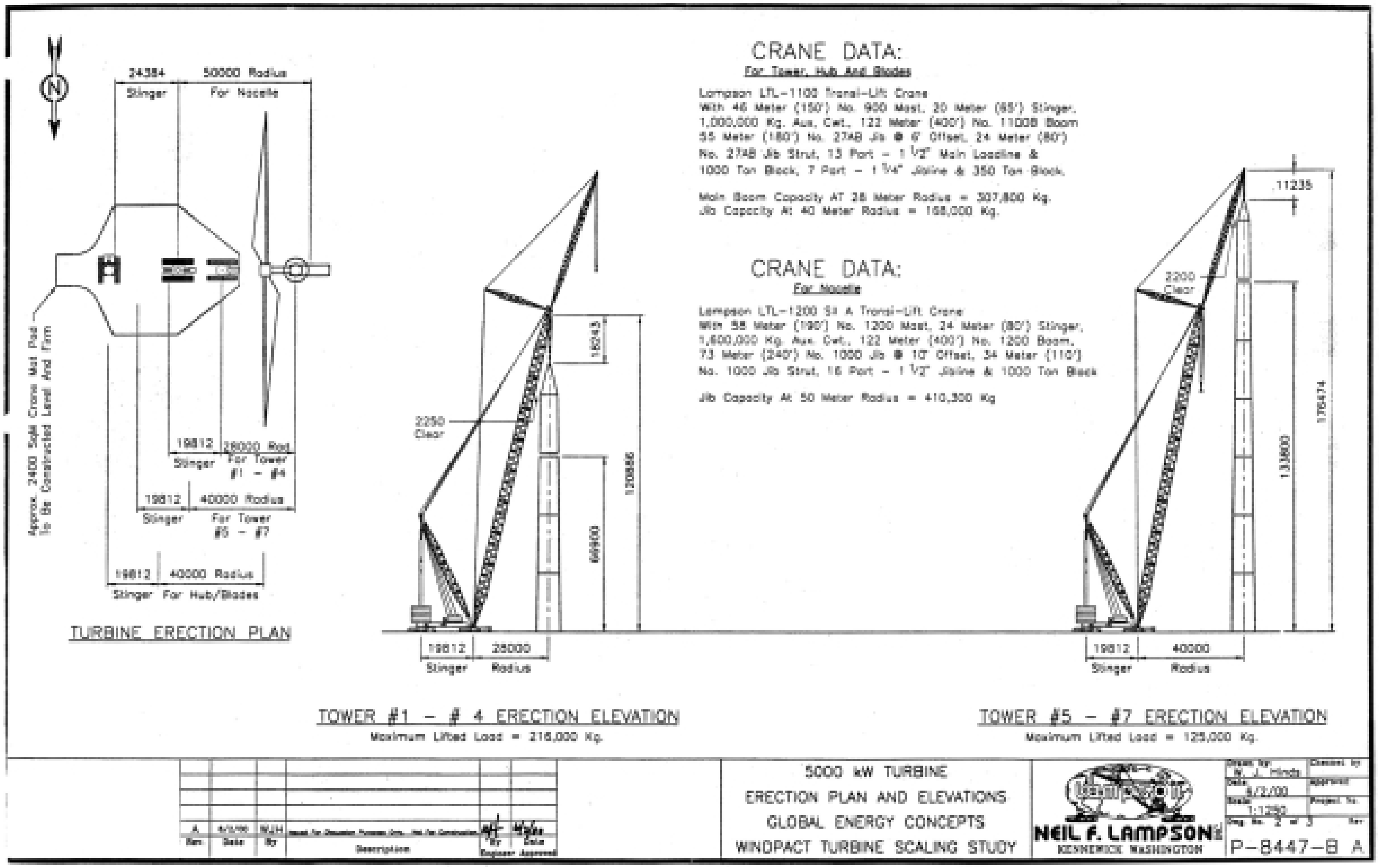


Figure 4-4.3500 kW crane
(Measurement units: mm)

Figure 4-5.5000-kW crane
(Measurement units: mm)



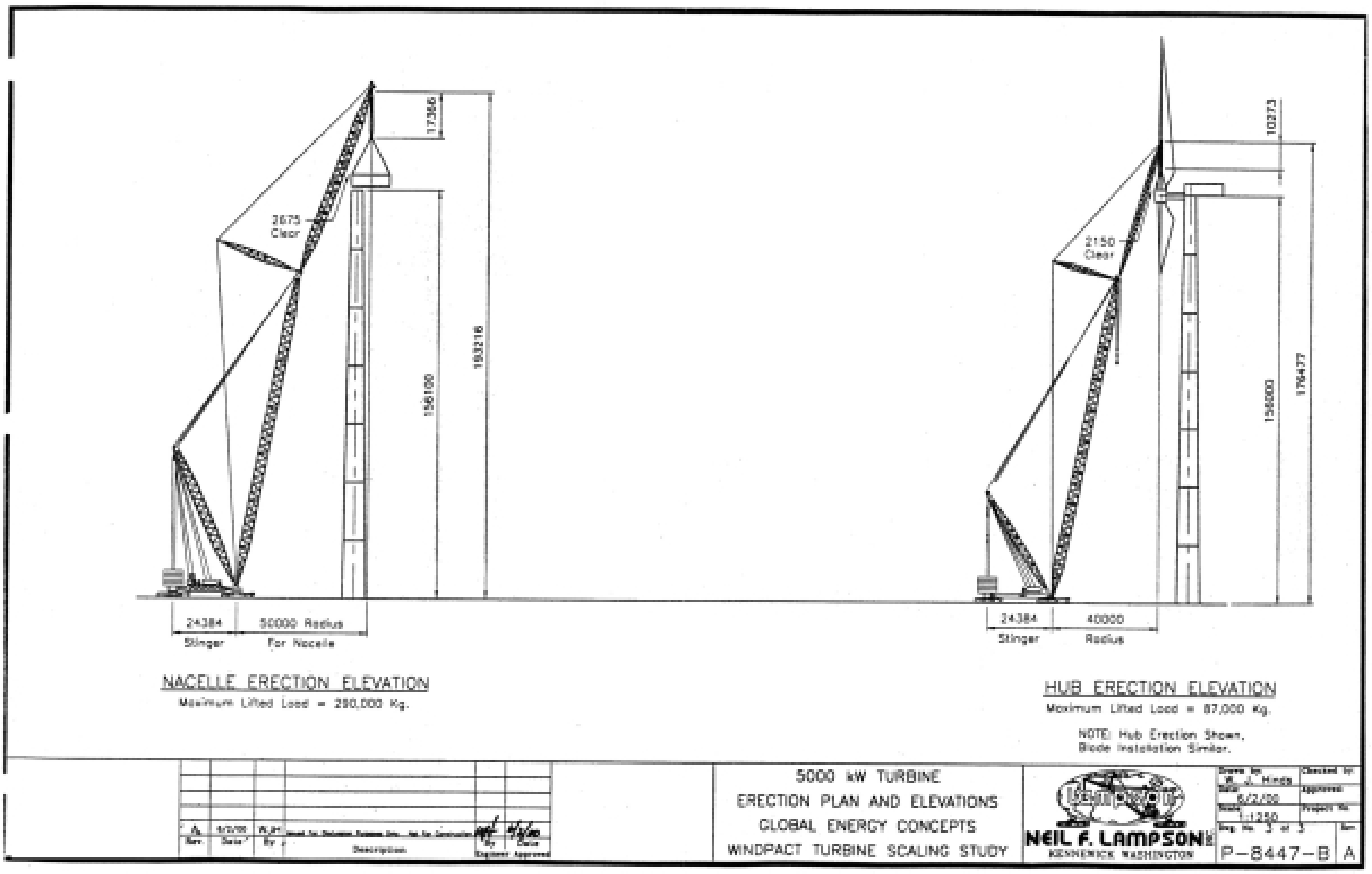


Figure 4-5.5000-kW crane (Continued)
(Measurement units: mm)

The time a crane remains on the project site will govern the crane costs. Based on input from Mortenson, the calendar time the crane would be on-site was estimated to equal the calendar time required for assembly of the towers, nacelle and rotors for all the turbines. The other turbine assembly activities can be conducted with the typical construction equipment without the high capacity crane. The total man-hours for the tower, rotor, and nacelle assembly tasks were divided by the total daily man-hours available to arrive at the estimated crane time per turbine. Then, crane relocation time between turbines was added to the crane's turbine assembly time to obtain a total crane operation time per turbine. The result of this approach was consistent with Mortenson's experience.

4.3 Analysis of Scenarios

The three basic scenarios discussed in Section 2.2 are analyzed in the following sections. Scenario 2 (in which the towers are sectioned lengthwise) includes analysis of three possible approaches for tower field assembly based on utilizing bolting, manual welding, and automated welding assembly techniques.

The crane costs (associated with turbine assembly) discussed in this section have been prepared under the assumption that one crane is assembling 50 turbines without being fully disassembled during relocation between turbines. This is considered optimum crane utilization. Based on actual experience, site terrain, soil conditions, and road construction significantly impact the mobility of high capacity cranes. In reality, more frequent crane disassembly and reassembly to facilitate relocation between turbines occurs during construction of wind farms. The terrain effects on the optimum crane costs discussed below are analyzed in Section 4.4.

4.3.1 Scenario 1

Figure 4-6 presents a summary of the general assembly and crane costs estimated for Scenario 1. Considering the turbine components are arriving on-site pre-assembled, this scenario would be expected to result in the lowest construction costs. The overall combined assembly and crane costs remain generally stable through the 2500 kW turbine, however, the 3500 kW and 5000 kW turbines experience increases to the combined cost per kW. As the turbine sizes increase (in particular as the height increases) the crane costs assume a higher portion of the combined costs.

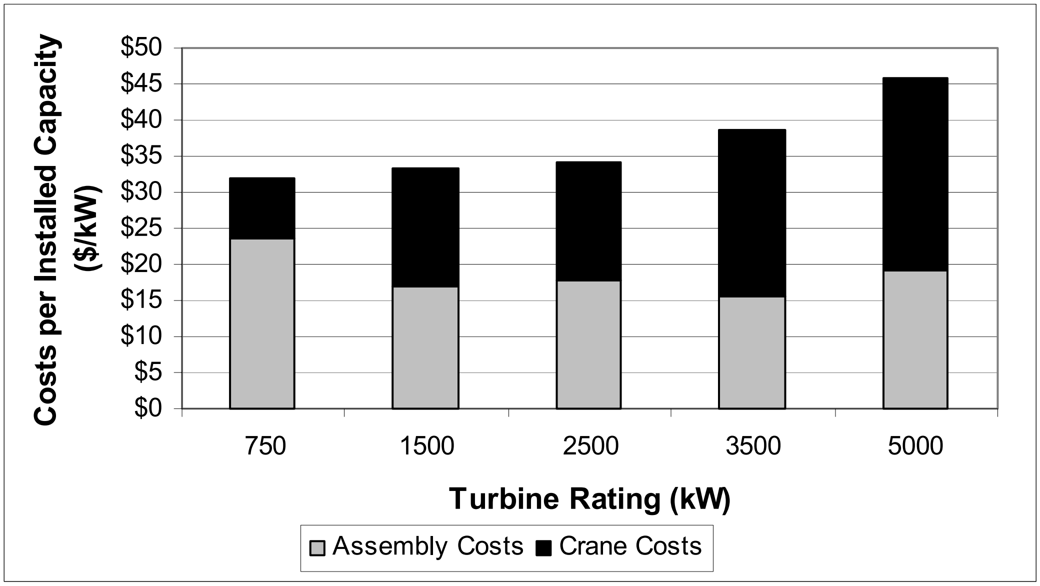


Figure 4-6.Scenario 1 assembly and crane costs
(See Appendix P, page 6)

Assembly
Although considerable increases in the level of effort are estimated for assembling the megawatt scale turbines, with estimated assembly costs per turbine ranging from $13,000 to $70,000, there is a general decrease in the assembly costs per kW through the 3500 kW turbine. A slight increase is noted for the 5000 kW turbine. The largest decrease in assembly costs per kW occurs between the 750 kW and 1500 kW turbines. Experience has indicated that there is not a significant difference in the level of effort required to assemble a 1500 kW turbine as opposed to a 750 kW turbine. The largest impact is derived by the height increase and to a lesser extent the increase in component sizes, however, the increase in rated power exceeds the modest increase in assembly effort.

Cranes
On a cost per turbine basis, the crane costs increase as the turbine sizes increase, however, a plateau in the costs per kW was identified at the 1500 kW and 2500 kW turbines even though different cranes are being utilized. Analysis of the cranes' lifting capacity for each turbine was performed to determine the cause. Figures 4-7 through 4-11 demonstrate the relationships between the mass and height requirements for each turbine component with respect to potential cranes. These figures demonstrate that the nacelle is the object that ultimately determines the specified crane. Aside from the 750 kW turbines, the boom elevations required to lift the nacelle are essentially the maximum elevation possible for the specified cranes. Typically the boom point elevation is 15 to 20 m (50 to 65 ft) greater that the hub height to allow space for blocks and rigging, additional clearance of the tower, and clearance between the nacelle and boom (or jib if being utilized).

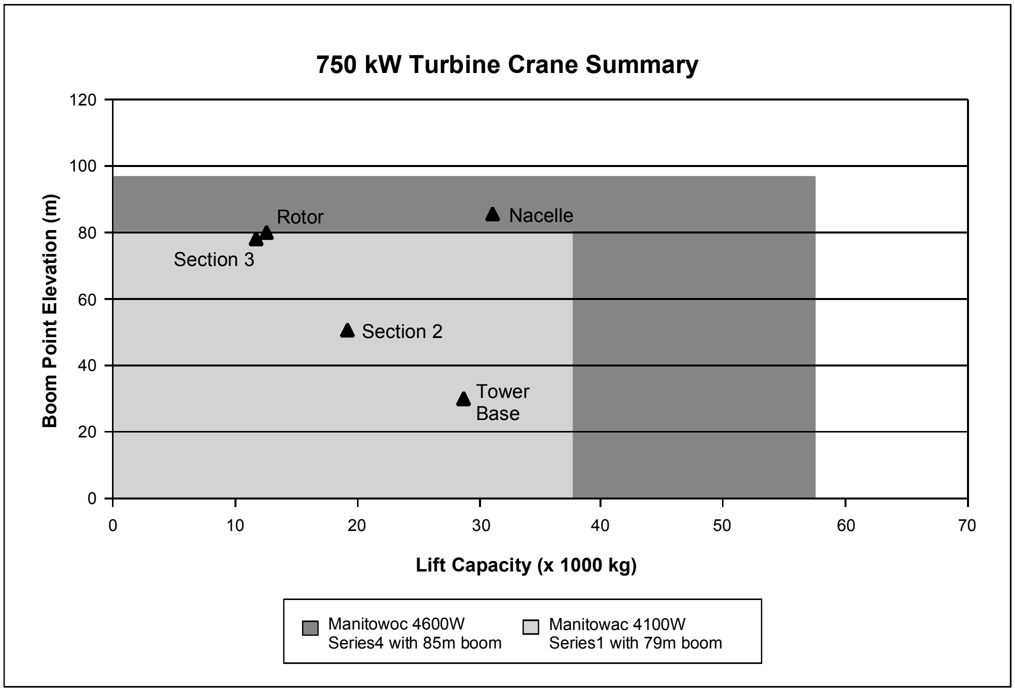


Figure 4-7.750-kW turbine crane summary

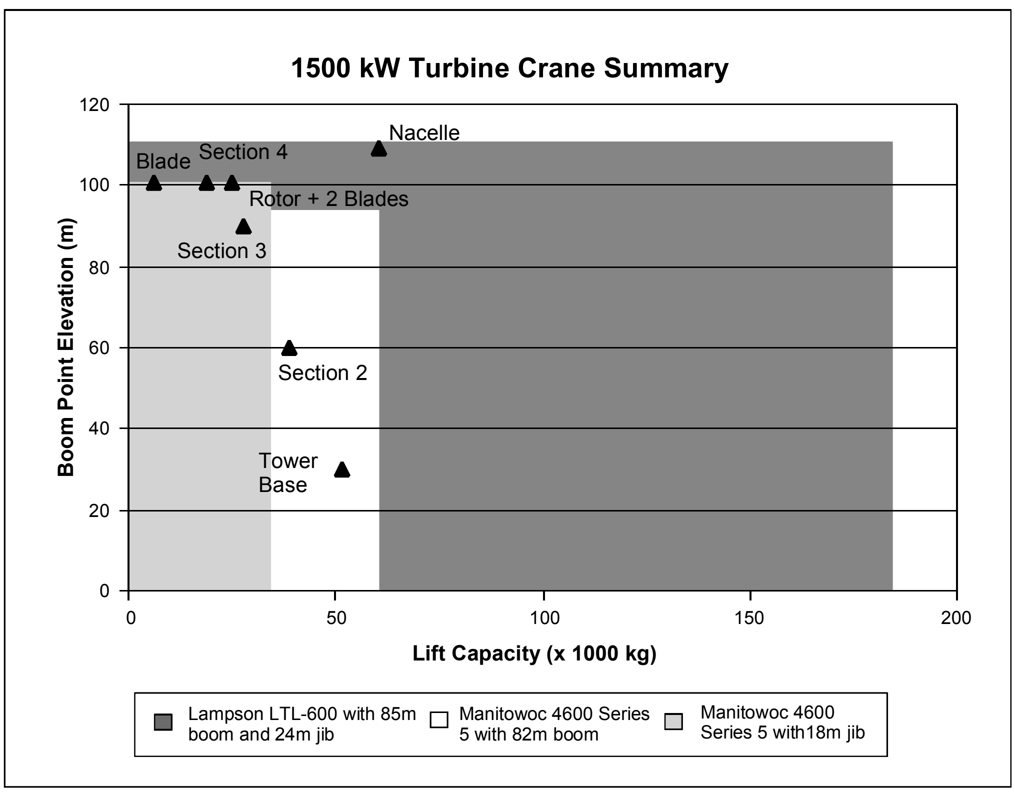


Figure 4-8.1500 kW turbine crane summary

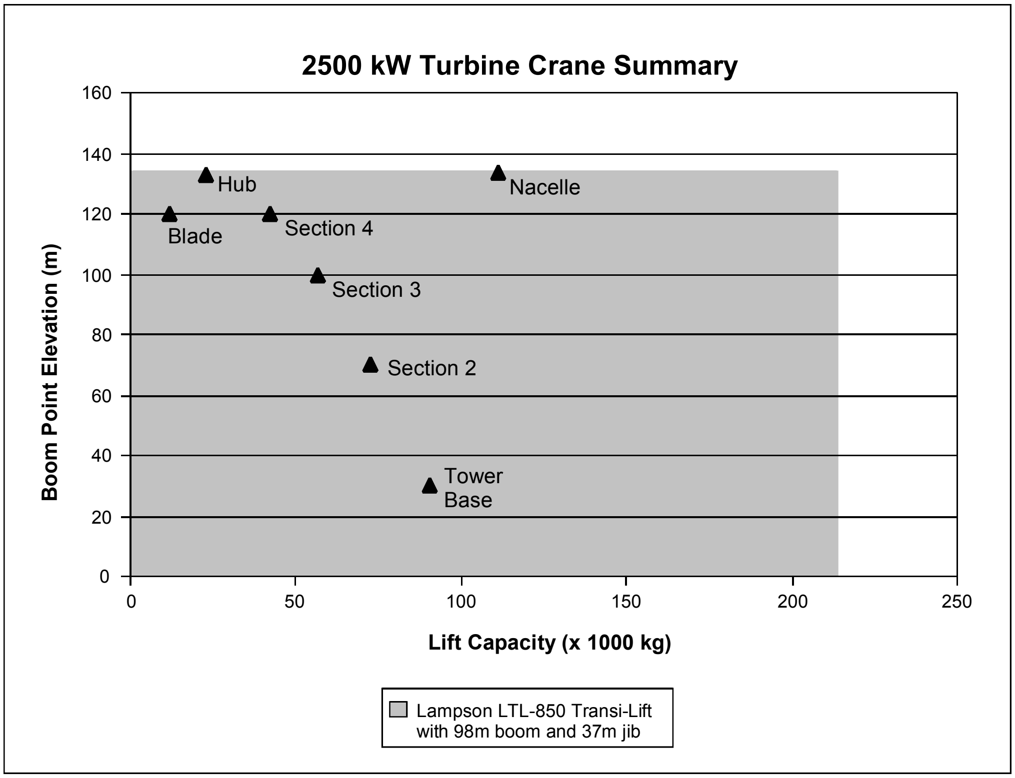


Figure 4-9.2500-kW turbine crane summary

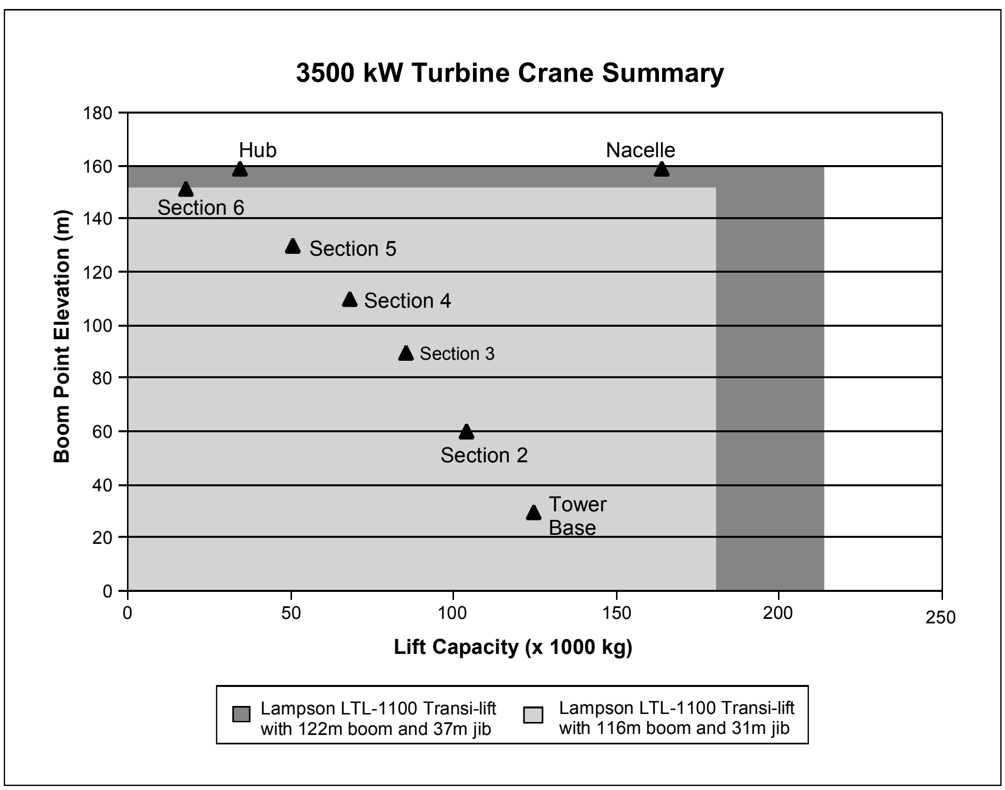


Figure 4-10.3500-kW turbine crane summary

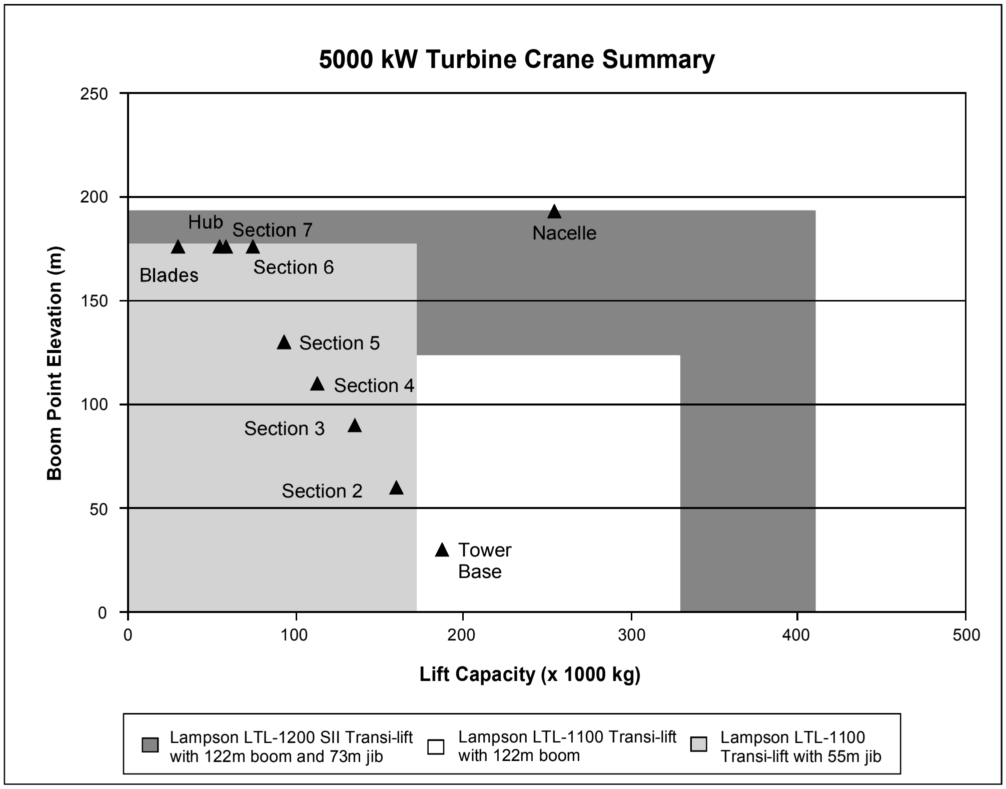


Figure 4-11.5000-kW turbine crane summary

The nacelle mass is generally at or within 50% of the total lifting capacity of the specified crane except the 1500 kW turbine, where the nacelle mass is only 35% of the total lifting capacity. It is apparent in Figures 4-7 through 4-11 that the crane industry generally has a greater need for lifting capacity that height. This is in sharp contrast to the wind industries need for height and.opposed to lifting capacity. The result is that cranes with significant excess capacity are used to obtain the required installation heights

The 86m hub height for the 1500 kW turbine eliminated the possibility of utilizing a 350-ton Manitowoc 4600 Series 5 crane with a base monthly rental of $37,500. This resulted in the need for a 600-ton Lampson LTL-600 crane with a base monthly rental of $90,000. Lampson noted that it might be possible to modify the Manitowoc 4600 Series 5 crane by adding a stinger attachment and a customized jib; however, the resulting monthly rental costs would be approximately $70,000 to $80,000. The hub height and masses of the 1500 kW WindPACT turbine identified a void in the crane market where a 350-ton crane with a possible boom elevation of 110 m (360 ft) does not exist. In addition, there is a significant jump in the costs of cranes between the 350 ton and 600 ton capacity range.

Finally as the crane capacity increases, the number of available cranes decrease. Figure 4-12 demonstrates the sizable decrease in crane quantities as the capacities increase. This information is based on historic crane data (1997) compiled by the Chicago Bridge and Iron Company and contained data from 18 crane manufacturers. Although newer crane models produced since 1997 would likely change the absolute values at the different crane capacities, the overall trend of the data has not unchanged.

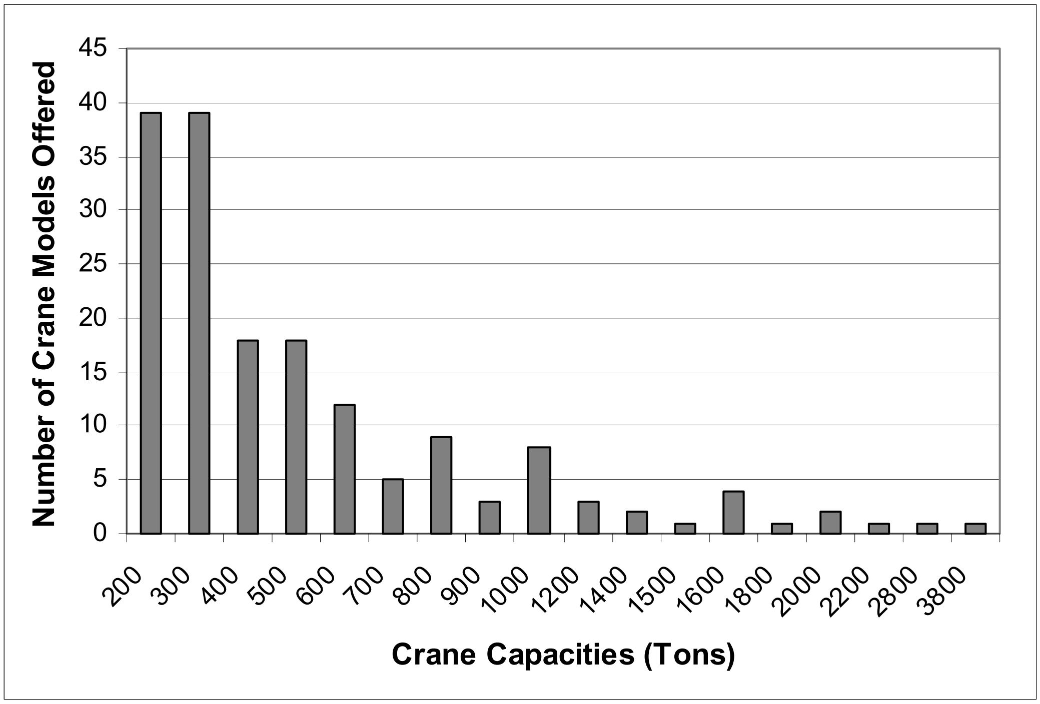


Figure 4-12.Crane capacity trends.
(See Appendix P, Page 7)

Whereas the excess crane capacity for the 1500 kW turbine results in the most inefficient crane usage, the 750 kW and 2500 kW turbines appears to be the most optimized. If the rotor diameter and hub height ratios for the 3500 and 5000 kW turbines are assumed to be close to 1 [resulting in hub heights of 100 m (328 ft) and 120 m (394 ft), respectively], then 850-ton to 1000-ton cranes could be used resulting in very efficient crane utilization.

4.3.2 Scenario 2

This scenario estimates the impact of assembling quartered tubular tower sections to the project costs. In comparison to Scenario 1, the combined turbine assembly and crane costs under this scenario are greater, however the decrease in transportation cost more than offsets the increase. Three separate tower fabrication approaches were analyzed with bolted connections and automated welding yielding lower costs than manual welding. The relative difference between automated welding and bolting was minor with bolted connections achieving the lowest costs. Additional material costs have been included in the estimates, however, the total impact on tower material costs was uncertain.

Figure 4-13 presents a comparison of the various assembly costs by tower assembly approach.

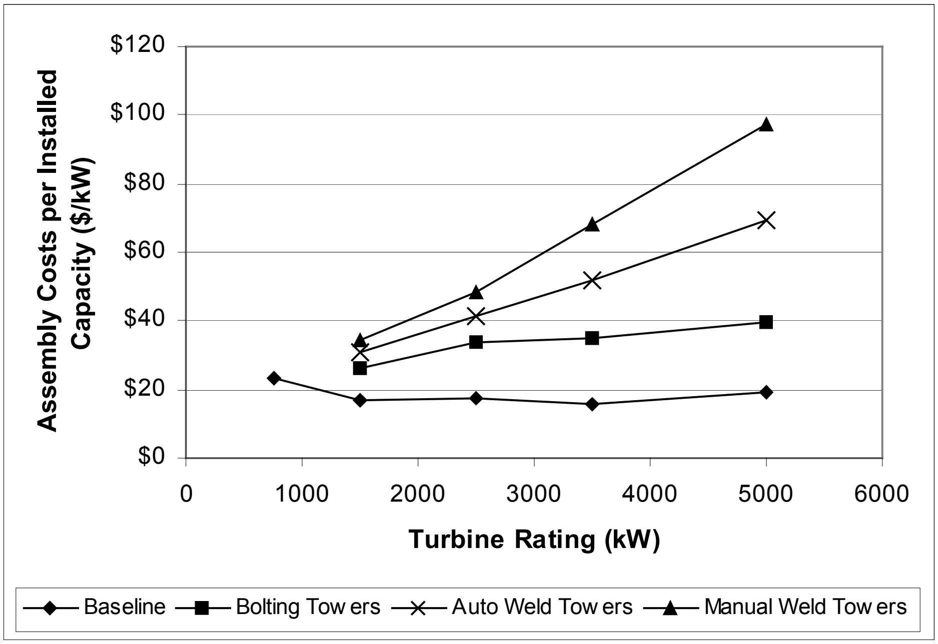


Figure 4-13.Assembly costs by scenario
(see Appendix P, page 8)

Assembly
The turbine assembly process was relatively unchanged from Scenario 1. The only minor assumption change was that the rotor assembly would occur with the hub attached to the nacelle on the tower top. In Scenario 1, it was assumed that the rotor would be lifted in one piece to the maximum extent possible. However, Lampson believed that less time would be lost to wind by lifting individual components as opposed to an entire rotor. The rotor assembly hours between Scenario 1 and 2 were increased 10% based on Mortenson's opinions. The corresponding change to costs per turbine and costs per kW was negligible in comparison to the increase in assembly time required for the tower sections.

To assemble the tower sections it was assumed that four concrete pads would be built on which the fabrication would be performed. The assembly area would be located in one portion of the project site and assembled tower sections would be transported to the turbine locations. Assembly of four quartered sections into two half sections would each take place on one pad. Jigs, templates, and blocking supports would be used to accurately align and secure the sections before assembly. On a third pad, two half-tower sections would be assembled into one tower section. The forth pad would be used for final inspection, painting, and staging for transport to the turbine site. More weather protection would be required for the welding approaches as opposed to the bolting approach.

The added on-site fabrication activity changed the assembly cost per kW from a decreasing trend in Scenario 1 to an increasing trend. The only difference in Scenario 2 is the rate of increase. In general, the bolting approach added approximately $20 to the Scenario 1 assembly costs per kW, whereas manual welding added $20 to $80 to the Scenario 1 assembly costs per kW. However, these added costs are much less than the decrease in transportation costs realized through the shipment of quartered tower sections. Figure 4-14 presents combined turbine assembly and crane costs associated with use of quartered tower sections. Table 4-1 presents the worst-case scenario comparing changes in short haul transportation costs with increased in on-site assembly and crane costs utilizing manual welding.

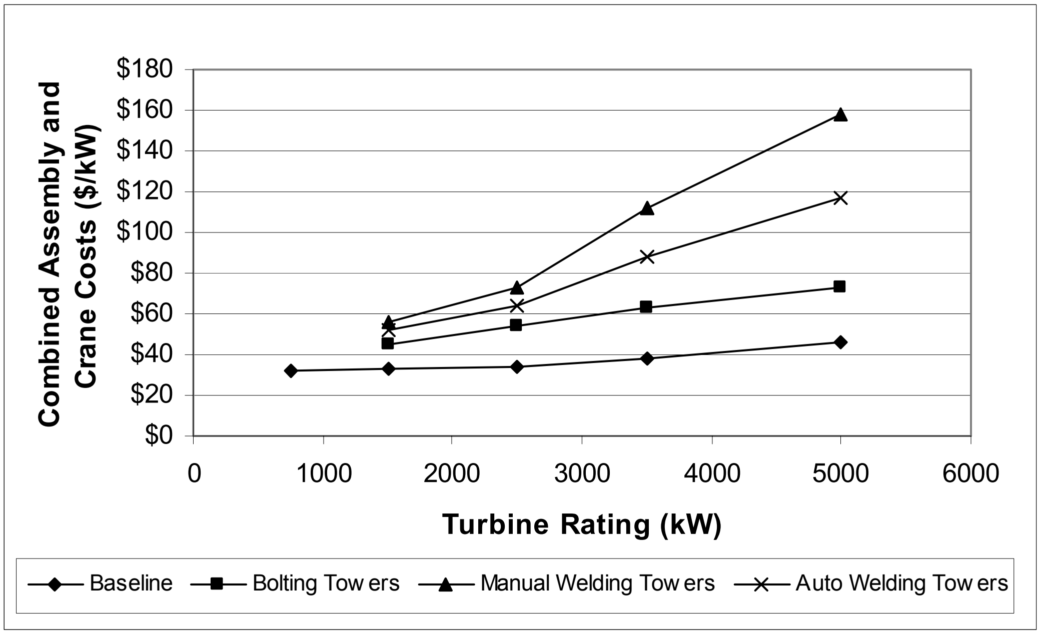


Figure 4-14.Combined assembly and crane costs by scenario
(see Appendix P, page 9)

Table 4-1.Impacts of Sectional Towers on Project Costs (Units:$/kW)

	2500 KW	3500 KW	5000 KW	NOTES
Scenario 1 Transport Costs (Short Haul)	$528	$691	$754	Appendix B, Page 2
Scenario 2 Transport Costs	$45	$76	$113	
Cost Savings:	**$-482**	**$-615**	**$-642**	
Scenario 1 Assembly and Crane Costs	$34	$38	$46	Appendix P, Page 9
Scenario 2 Assembly and Crane Costs (Manual Welding)	$73	$112	$158	
Cost Increase:	**$39**	**$74**	**$112**	
Net Effect:	**$-443**	**$-541**	**$-530**	

Considering the excessive transport costs incurred by attempting to move numerous intact tower sections, a significant amount of on-site assembly could be utilized. The impact that on-site tower fabrication has in reducing transportation costs is considerable and appears to be the logical approach to utilization of tubular towers greater than 85 m (279 ft) in height that utilize diameters greater than 4.4 m (14.4 ft). If tubular towers are to remain the industries preferred tower approach, then on-site fabrication will be a necessity. Although interior tower dimensions can be adjusted slightly, it appears that the utilizing intact tubular tower sections make sense from a logistic perspective up to hub heights of 80 to 85m (262 to 279 ft).

Cranes
No change to the turbine assembly cranes selected in Scenario 1 was made. One additional crane was added to the cost estimate to account for fabricating the towers on-site. Since the mass and lifting height requirements were not significant, readily available and cost effective 200-ton and 350-ton cranes were selected for activity.

4.3.3 Scenario 3

Under this scenario, assembly and crane logistics were further analyzed to determine the impact of assembling the gearbox and generator into the nacelle while atop the turbine tower. The intent was to determine if reductions in the masses of the objects being lifted resulted in ability to use a different crane and if the added assembly costs were greater than any potential crane savings. Table 4-2 presents the lifting parameters used to evaluated Scenario 3. Gearbox and generator masses were estimated using criteria presented in reference [1]. Under Scenario 3 the ‘empty’ nacelle mass becomes the critical object for crane selection. Applying the combined 25% nacelle mass reduction (for the gearbox and generator) to the nacelle points shown in Figures 4-7 through 4-11 (without modifying the required boom point elevation) failed to result in the ‘empty’ nacelle mass point entering the capacity range of a smaller crane. The conclusion was that removal of the gearbox and generator did not sufficiently reduce the remaining mass of the nacelle to result in a crane modification. Analysis of the crane information presented in Section 4.3.1 combined with the ‘empty’ nacelle masses reveals that reducing the hub height (and corresponding boom point elevation) is a more effective means of reducing crane costs.

Table 4-2.Nacelles and Components Lifting Parameters

	Units	Turbine Ratings					Notes, References, Assumptions
	kW	750	1500	2500	3500	5000	
Total Nacelle Mass	kg	31,081	60,517	111,065	164,049	254,102	EWEA document. Figure 4.6.3 m = 2.60D2.4
Gearbox Mass	kg	4,662	9,078	16,660	24,607	38,115	Estimated as 15% of Nacelle mass
Generator Mass	kg	3,108	5,267	8,567	11,867	16,817	Estimated at 10% of Nacelle mass
Empty Nacelle Mass	kg	23,311	46,173	85,839	127,575	199,170	
Hub Height	m	65	86	111	130	156	Used ratio of tower height/rotor diameter of 1.3 per SOW.
Boom Point Elevations	m	85	109	133	159	193	Point elevations determined by Lampson for load, height, equipment-lifting capacity, clearances, and safety margin.

Assembly
Disassembly of the nacelle’s major components did not result in a beneficial impact to the nacelle transportation costs as discussed in Section 3.5.3 and it caused a slight increase to the assembly

costs. The minor transportation cost savings obtained for the 5000 kW nacelle was offset by the increase in assembly costs resulting in an insignificant change in costs between Scenario 1 and 3.

Cranes
The only adjustment to crane costs between Scenario 2 and 3 is reflected by the increased crane time required for installing the gearbox and generator. The crane cost increased an estimated $2 per kW, resulting in a total increase of $4 per kW. Combined crane, assembly, and transportation costs for the 3500 kW turbine actually increase slightly under Scenario 3 while these costs remain unchanged for the 5000 kW turbine.

4.4 Terrain Effects on Crane Costs

To evaluate terrain effects on crane costs, the effort, costs and time required for crane assembly and disassembly included in crane mobilization and demobilization estimates were utilized. Fully assembled cranes do have the capability to move under optimum conditions without necessitating partial or full disassembly. However, topography at valuable wind sites with ridgelines, rolling terrain, or mesas pose significant impediments to crane movements. Turbine layout also impacts crane movement with grid configurations representing the most conducive and dispersed turbine clusters representing the most challenging.

To estimate the terrain impacts, crane disassembly and reassembly costs, in addition to those incurred during mobilization and demobilization, where calculated and added to the original crane costs. The costs include labor, crane rental, additional support cranes, and transport vehicles. Optimum crane costs (utilized in Section 4.3) represent the costs of assembling 50 turbines without any additional crane disassembly/reassembly being incurred. As the assumed number of crane disassemblies increases, the number of turbines installed between crane disassemblies decreases. The assumption is that as the terrain becomes harsher, the number of turbines that could be installed between crane disassemblies decreases. Therefore, assembly of 50 turbines per crane disassembly represents optimum crane use for the hypothetical WindPACT project. Assembly of 2 turbines per crane disassembly represents extremely harsh terrain. Based on the rolling topography of south central South Dakota, the numbers of turbines assembled per crane disassembly has been estimated to be 10 to 25 (depending upon the assumed turbine layout).

Figure 4-15 presents the increases to the optimum crane costs due to terrain effects. Incurring one crane disassembly (corresponding to 25-turbines/crane disassembly) resulted in a moderate cost increase of 12%. However, incurring four crane disassemblies (corresponding to 10-turbines/crane disassembly) resulted in a 50% cost increase. The well-matched crane capacities for the 750 kW and 2500 kW turbines (discussed at the end of Section 4.3.1) are magnified when terrain effects are accounted for. This is evident by a lower rate of cost increases for these turbines. For the cranes associated with the 1500 kW and 2500 kW turbines, there is only a modest increase in the base monthly rates and level of assembly effort, however the increased power rating of the 2500 kW turbine improves the cost environment.

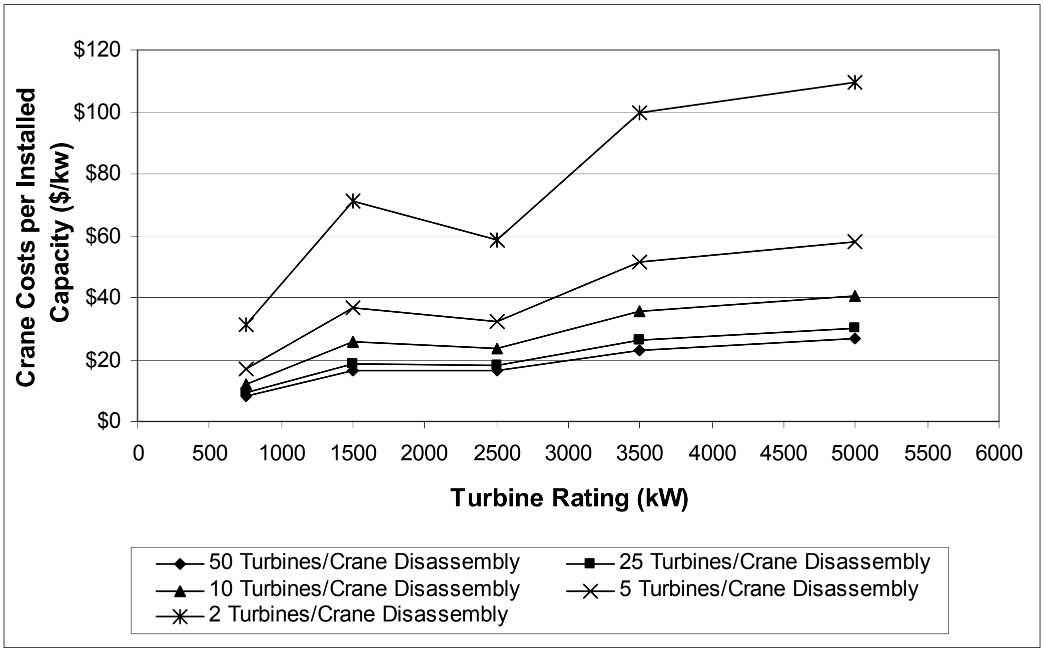


Figure 4-15.Terrain effects on crane costs
(see Appendix P, page 10)

Another area that terrain issues associated with cranes impacts a project is related to schedule. Figures 4-16 and 4-17 demonstrate increases to turbine assembly rates (days/turbine) and overall duration of assembly activities (months), respectively. The differences between a 1500 kW and 5000 kW turbines are shown for illustration purposes. Significant increases to project duration for both turbine sizes caused by terrain issues would likely have an adverse impact to project financing.

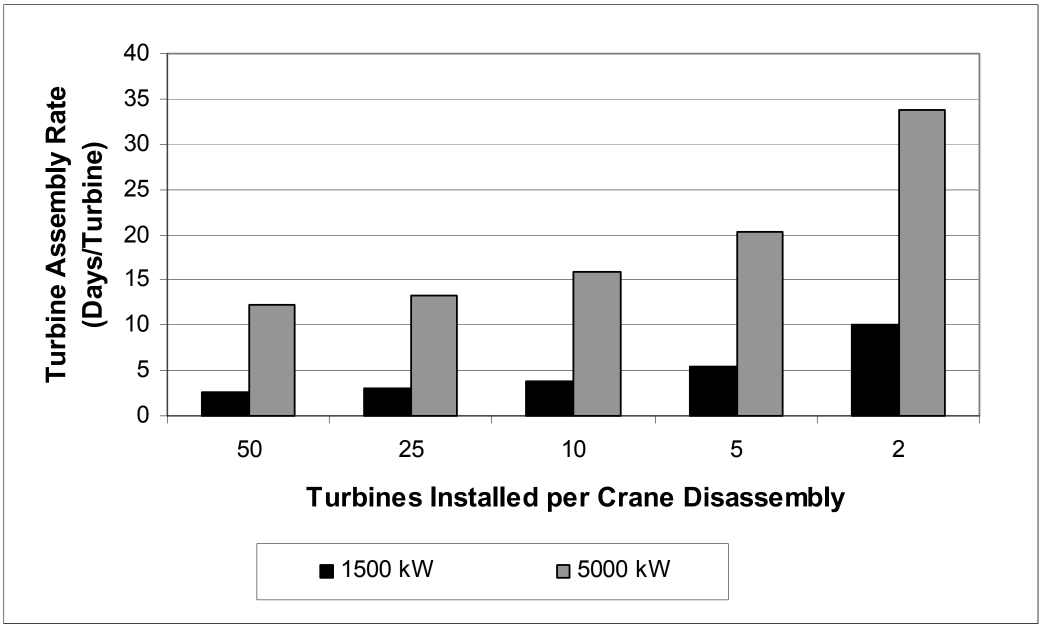


Figure 4-16.Influence of terrain impact to turbine assembly rates
(see Appendix P, page 11)

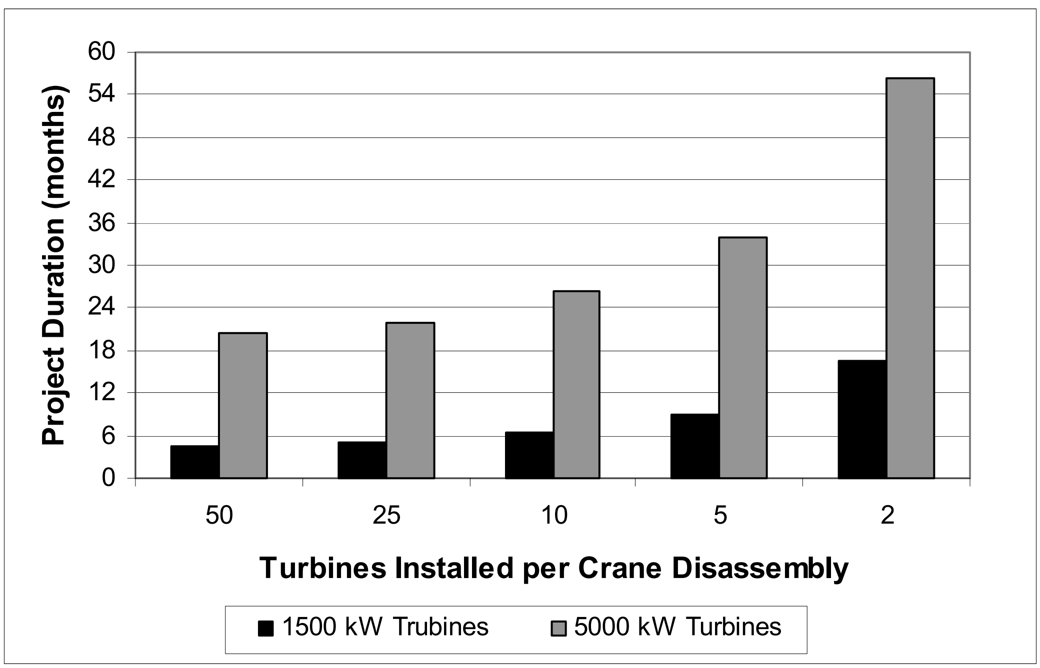


Figure 4-17.Influence of terrain impacts on project duration
(see Appendix P, page 12)

4.5 Crane Purchase Evaluation

Purchase costs were evaluated to determine if a measurable benefit of crane ownership exists in comparison to crane rental. Cranes selected for the evaluation were large enough to perform individual blade, gearbox, and generator removal; however, they lacked capacity to remove the entire rotor or nacelle. These cranes were assumed to be indicative of the type of 'service cranes' that a large facility would consider owning. Purchase costs for the cranes were compared to loaded hourly rental rates using the standardized cost of energy equation in EPRI's Technical Assessment Guide [12]. The COE equation was set equal to 0 then the crane annual O & M expenses were solved for based on capital crane costs and the fixed charge rate (assuming that all other cost components remained unchanged). A fixed charge rate of 10% was assumed. Using the loaded hourly crane rental rates, annual crane usage was then calculated from the annual crane O & M expenses. If the annual crane usage rate is low, then crane purchase costs could be recovered quickly and ownership would be favorable. Table 4-3 presents the calculations and results.

Table 4-3.Crane Purchase Evaluation

Turbine	kW	750	1500	2500	3500	5000
Rotor Dia	m	50	66	85	100	120
O & M Crane Type		4100-S1	4600-S4	LTL-600	LTL-600	LTL-1000
Crane Purchase Costs		$1,150,000	$2,250,000	$3,500,000	$3,500,000	$6,500,000
Fixed Charge Rate		0.1	0.1	0.1	0.1	0.1
Capital Costs x F.C.		$115,000	$225,000	$350,000	$350,000	$650,000
Loaded Hourly Operation Rate		$375	$490	$920	$920	$1,030
Annual Usage	hrs	307	459	380	380	631
Annual Usage	Months	1.7	2.6	2.2	2.2	3.6
Total Usage for 20 year project	hrs	6133	9184	7609	7609	12621
Usage every 3 years:	Months	5	8	6	6	11
Usage every 5 years:	Months	9	13	11	11	18

See Appendix S

Using the 750 kW turbines as an example, crane purchase would be more favorable than rental when crane usage exceeds 307 hours (or 1.7 months) for each year of the project. This usage rate would not be achievable (or desired) at one project with 50 turbines. A reasonable crane usage estimate would be 1 month or less per year. As the turbine sizes (and service crane sizes) increased, higher crane usage rates are necessary to make crane ownership cost effective.

If crane usage were distributed across 3 or 4 other projects (assuming similar number and size of turbines), then it is conceivable that the annual usage rate could be met making crane ownership more cost effective. However, a large crane purchased for 5000 kW turbines would not be effective at projects comprised of smaller turbines because the mobilization, assembly, and relocation time would be excessive in comparison to a rented crane properly sized for the specific turbines. Another drawback to distributing crane usage across other projects in the region is that generally small windows of low wind months exist during which O & M work requiring cranes is performed. It's likely that scheduling crane work for multiple projects would result in conflicts, necessitating crane rental at one or more projects, eroding the potential benefit of crane ownership. Crane ownership may be beneficial for very large projects of smaller turbines (for example 200 –750 kW turbines) under control of one owner. However, for most projects, crane rental remains more cost effective.

5. Summary Analysis

5.1 Logistic Costs by Scenario

The combined analyses of transportation, assembly, and crane logistics costs have been summarized in Figures 5-1, 5-2, and 5-3 below. We combined mid-range assembly and crane costs with long-haul transportation costs to generate the total values in the figures. The crane costs in these figures have not been adjusted for terrain effects; they therefore correspond to optimum crane utilization. The reduction in transportation costs associated with quartered tower sections is evident in the cost reduction between Figures 5-1 and 5-2. Figure 5-3 demonstrates that when field assembly of the gearbox and generator into the nacelle is included (in addition to quartered tower sections), there is virtually no change in total logistics costs. The latter increase with increasing turbine size, however, the rate of increase can be reduced the most by utilizing field fabrication of towers.

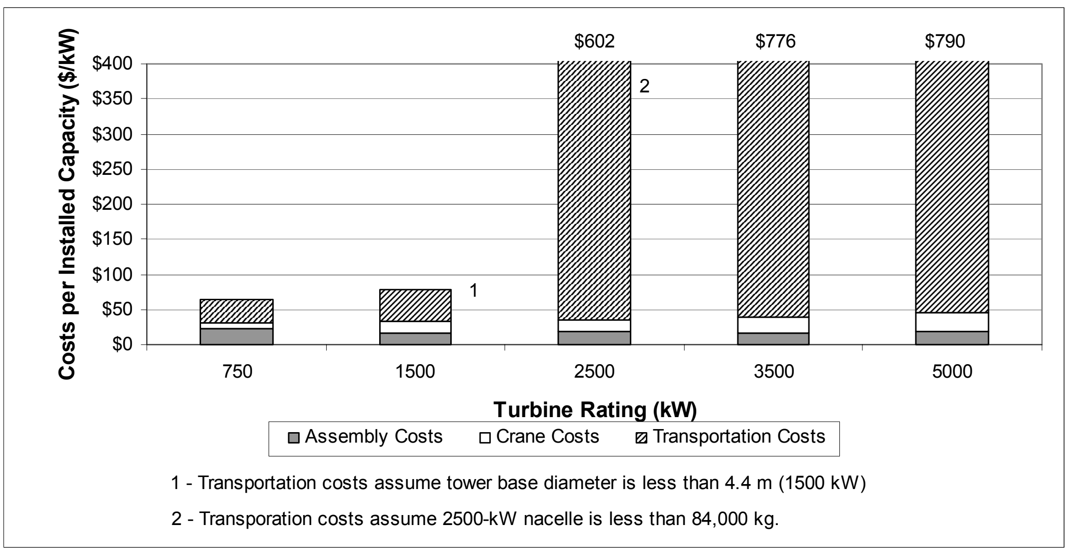


Figure 5-1.Scenario 1 cost components
(see Appendix P, page 13)

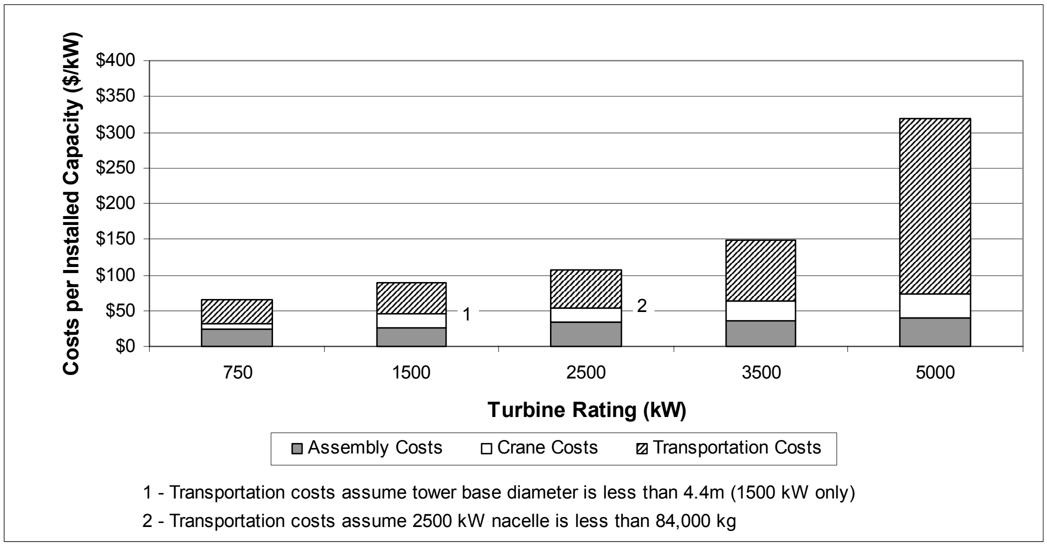


Figure 5-2.Scenario 2 cost components
750 kW and 1500 kW costs are same as Scenario 1 (see Appendix P, page 13)

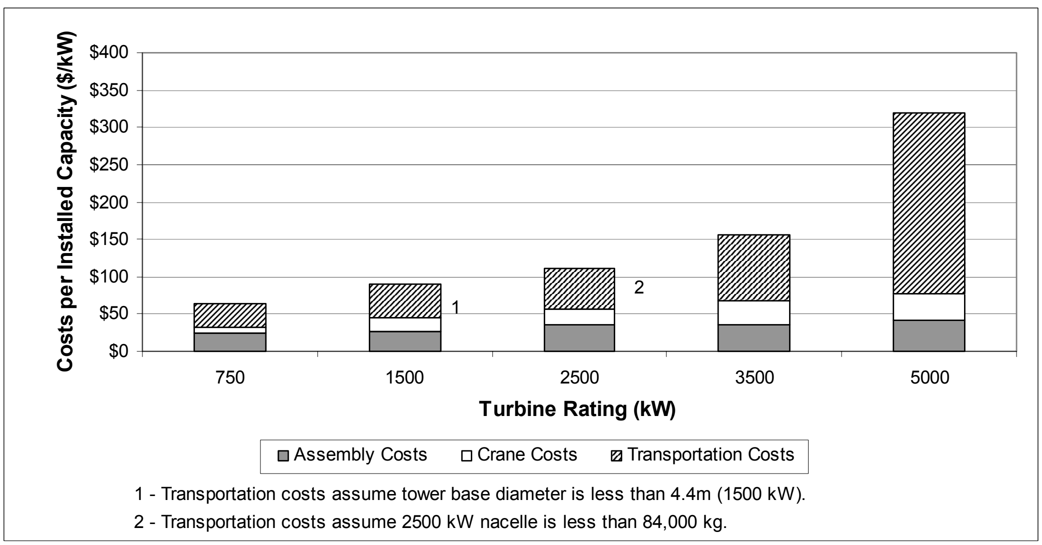


Figure 5-3.Scenario 3 cost components
750 kW and 1500 kW costs are same as Scenario 1 (see Appendix P, page 14)

5.2 Logistic Costs for South Dakota Site

To provide representative costs we performed a detailed analysis of logistic costs for Scenario 2 (Figure 5-2) with respect to the hypothesized South Dakota project site. We assumed that quartered tower sections would be used for 2500 kW and greater turbines, and that the turbine components would be shipped to South Dakota (assuming short-haul distances). Crane costs were adjusted for terrain by assuming that 10 turbines could be assembled before complete crane disassembly would be required, based on the rolling topography of south-central South Dakota and the assumption that dispersed turbine arrays would be used. Both of these factors would increase the potential for more frequent crane disassembly during crane relocation.

Figure 5-4 presents the representative logistics costs for 50 multi-megawatt turbines in South Dakota. Transportation costs are lower than those presented in Figure 5-2 because short-haul distances are being used. Crane costs are greater than those in Figure 5-2 due to adjustments for terrain. Figures 5-5 and 5-6 present scaling relationships of the logistic costs in Figure 5-4.

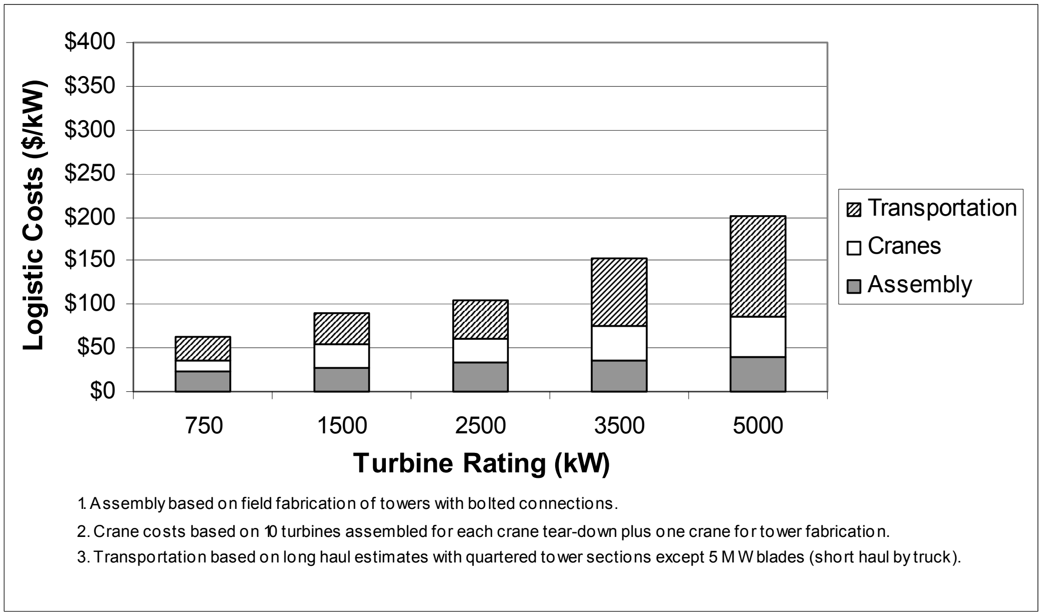


Figure 5-4.Logistic costs for multi-megawatt turbines in South Dakota
(see Appendix P, page 15)

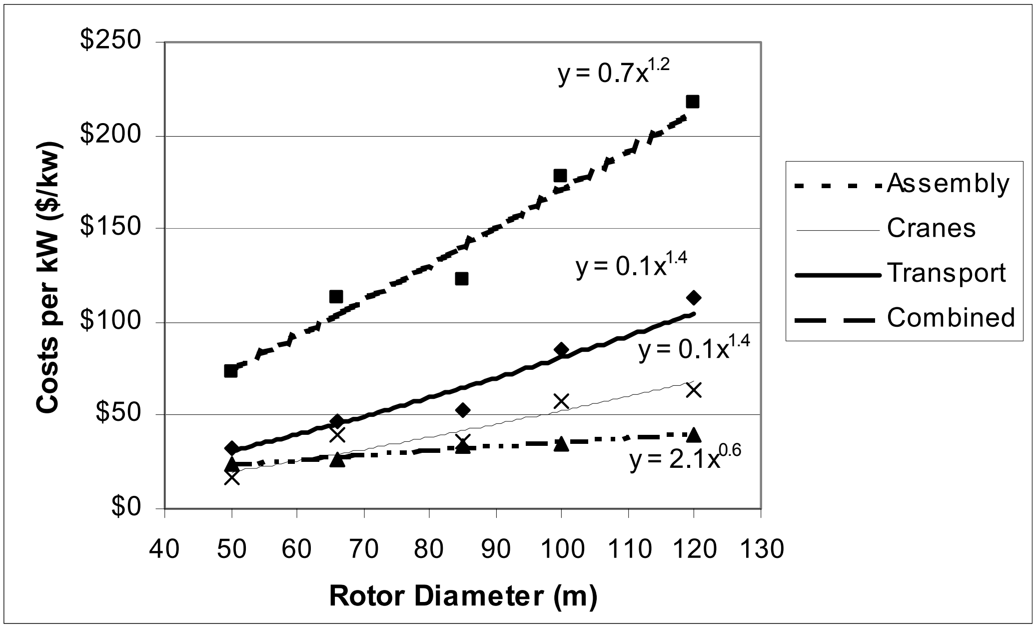


Figure 5-5.Scaling relationships by rotor diameter
(see Appendix P, page 15)

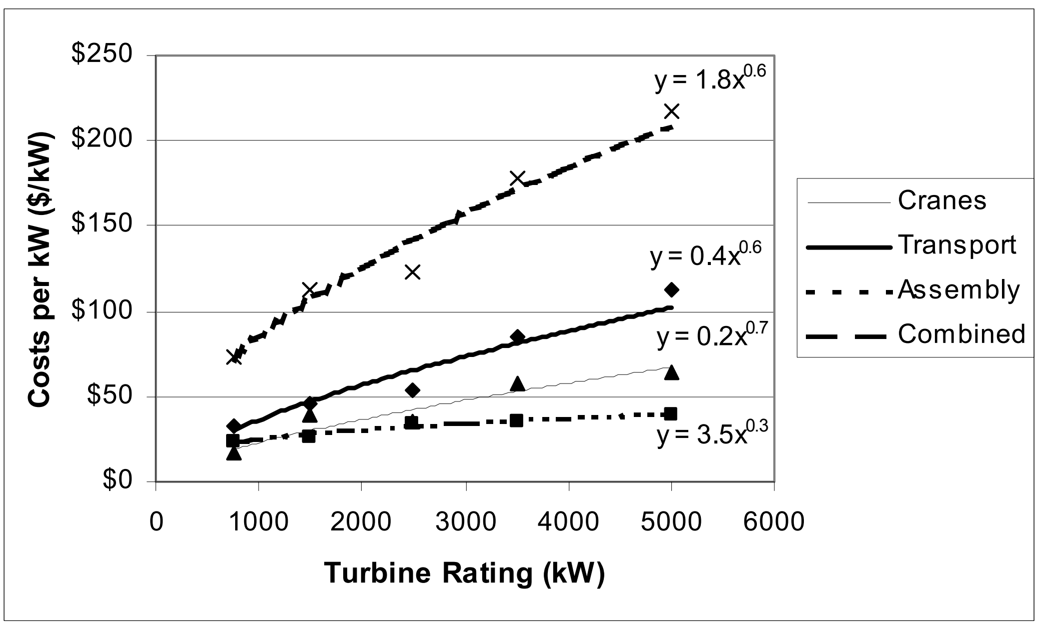


Figure 5-6.Scaling relationships by turbine rating
(see Appendix P, page 15)

5.3 Road-Width Analysis

On-site road widths and corresponding construction costs are determined to a large extent by the turbine transportation and assembly equipment associated with project logistics. Development of site road construction costs is a component of WindPACT Technical Area 4 – Balance of Station Costs; however, the road widths for equipment presented in this report have been summarized in Table 5-1. As indicated in this table, the road widths associated with larger cranes are significant and would be extremely expensive to construct in complex terrain.

Table 5-1.On-site Road Widths Based on Logistics Equipment

Turbine (kW)	Nacelle		Blades		Tower Sections		Crane	
	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)
750	4.6	15	4.6	15	4.6	15	4.6	15
1500	4.6	15	4.6	15	4.6	15	9.1	30
2500	4.6	15	4.6	15	4.6	15	9.1	30
3500	6.1	20	6.1	20	4.6-6.1	15-20	9.8	32
5000	6.1	20	7.5	25	4.6-6.1	15-20	12.2	40

5.4 Conclusions

The following conclusions can be made based on the combined analysis of transportation, assembly, and crane logistics:

Transportation

1. Of the three, transportation limitations and associated costs have the largest impact on total logistics costs. Different approaches used to reduce transportation costs by bringing the transported objects into common dimensional or reasonable constraints prove to be very cost effective, even when increased numbers of shipments are necessary. The U.S. transportation system is dominated by tractor-trailer transport, which results in a very competitive and efficient system. To obtain the most cost-effective transportation, movement of wind turbine components should utilize loads that remain within the standard trailer dimensions of 4.1 m (13.5 ft) high by 2.6 m (8.5 ft) wide and up to 80,000 GVW corresponding to a cargo weight of about 19,000 kg (42,000 lbs). Where this is not possible, the next most critical dimensions are height followed by weight. Loaded heights that exceed 4.83 m (15.83 ft) will trigger the need for extremely expensive utility and police assistance associated with temporary overhead utility disconnection and reconnection. These costs are extremely load and route dependant and are generally only acceptable for one-of-a-kind moves (when all alternatives have been exhausted). Attempting to move numerous objects that require this form of assistance will most likely not be allowed by local jurisdictions due to disruption to the community. This form of disruption can also have a detrimental impact to the perceived value of wind energy. Tractor-trailer transportation with object weights up to 84,000 kg (185,000 lbs) but within the height constraint is the next most cost-effective method, although it is generally ten times the costs of standard tractor-trailer movement. These loads will necessitate

oversized and overweight permits and come under tight scrutiny by enforcement officials. Above this weight range, dolly and rail transport become the preferred modes. Rail is best applied to dimensionally compliant and massive objects such as nacelles.

2. Alleviation of transportation issues associated with the towers results in the largest adjustment to the total logistics costs. The critical diameter dimension for transport of intact tubular tower sections is 4.4 m (14.5 ft) because diameters larger than this result in a total vehicle height exceeding 4.83 m (15.83 ft). The tower design used in this study for the 1500-kW turbine with an 86 m (282 ft) hub height resulted in a base diameter of 4.9 m (16 ft). The unexpected result of not being able to transport this base tower section by truck helped isolate the dimension issues associated with the towers. The transportation of intact tower sections as assumed in Scenario 1 obviously cannot continue for the tubular tower design without modification of the design approach. It is likely that tower designers will be able to achieve hub heights greater that 80 m (262 ft) on tubular towers with diameters fixed at the transportation limitation; however, it will result in less efficient material usage, increased tower costs, and increased weight. The transportation costs savings may allow these inefficiencies, but only to a point.

   The application of quartered tower sections demonstrated that extensive on-site assembly could be performed cost effectively because significant transportation cost savings are being attained. Tower design approaches that rely on increased field assembly appear to be the most effective technique for achieving hub heights in the range of 100 m with 85 m diameter rotors (comparable to 2500-kW turbines). However, once designers begin to investigate field-fabricated towers, other tower configurations may prove to be more cost effective than quartered tubular towers such as truss tower, guyed towers, combined tri-pod and tubular towers, and cast concrete. In addition, independent pitch control systems for each blade could help mitigate thrust loads imparted to the tower under various design loading scenarios.

3. Nacelle designs should recognize that 84,000 kg (185,000 lbs) is a breakpoint and maintain an overall vehicle height below 4.83 m (15.83 ft) in order to maximize the range of cost-effective truck transportation. Based on the nacelle mass scaling Equation 2.4, the above mass limit corresponds to a rotor diameter of 84 m (275 ft). For nacelles with total masses that exceed this limit, removal of the gearbox and generator for separate shipment is cost effective until the remaining nacelle mass is at this tractor-trailer transportation limit.

   For nacelles that can be fabricated within the dimensional limits of the railroad 4.2 m 14 ft wide and 3.7 m 12 ft above top of rail, rail's additional transport capacity up to 163,300 kg (360,000 lbs) could be used for turbines with 115-m (377-ft) diameter rotors.

4. The large physical dimensions of turbine components, coupled with relatively light masses, results in expensive water-based transportation costs. This mode of transport does not offer many advantages for wind turbine components other than the ability to by-pass certain states through which passage by land is not allowed.

5. Proximity of manufacturing to potential wind sites is most important for the 5000-kW turbines in order to minimize costly dolly transport distances and eliminate the use of waterway transport.

Assembly and Cranes

The turbine assembly and crane costs were small relative to the transportation costs for each of the three development scenarios. However, within these areas we identified the following valuable information.

Assembly

1. Although total assembly costs per turbine increase as the turbine sizes increase, the assembly costs per installed kW didn't experience dramatic changes, as indicated by the constant assembly values shown in Figure 5-1. The increased assembly effort associated with larger turbines does not appear to increase faster than the power rating of the turbines.

2. When field fabrication of the towers is used to reduce transportation costs, relatively modest ($20 to $30) increases in cost per kW are incurred. Of the possible on-site tower fabrication approaches, use of bolted joints with overlap steel panels was demonstrated to be more cost effective than manual or automated welding. The costs for field fabrication of towers with this approach did not experience a continued increase as the turbine sizes increased. Whereas welding costs depend on the wall thickness of the towers, this dimension does not adversely affect bolted connections. Both approaches are equally affected (adversely) by increased length of tower sections and increased number of sections requiring field fabrication.

Cranes

1. Crane costs were shown to increase as turbine size increased. However, the dimensions and masses of the 750-kW and 2500-kW turbines resulted in the most efficient use of the selected crane capacities. Cranes are very efficient when used to assemble numerous turbines (50 in this example) in benign terrain where grid layouts are possible. However, sharp increases in crane costs occur when multiple crane disassembly/reassembly is required to relocate the crane between turbines. Actual crane disassembly frequency is a function of the site characteristics and project layout. Assembly of a few 3500-kW or 5000-kW turbines on high ridges in harsh terrain will result in excessive crane costs.

2. The best approach to decrease crane costs is to decrease lifting-height requirements. Unfortunately, this conflicts with the wind industry's need for increased heights to increase annual energy production.

3. Although crane mobilization, assembly, and demobilization costs are considerable, use of cranes is cost effective for turbine assembly, even when excess lifting capacity is being incurred to attain the required heights.

6. References

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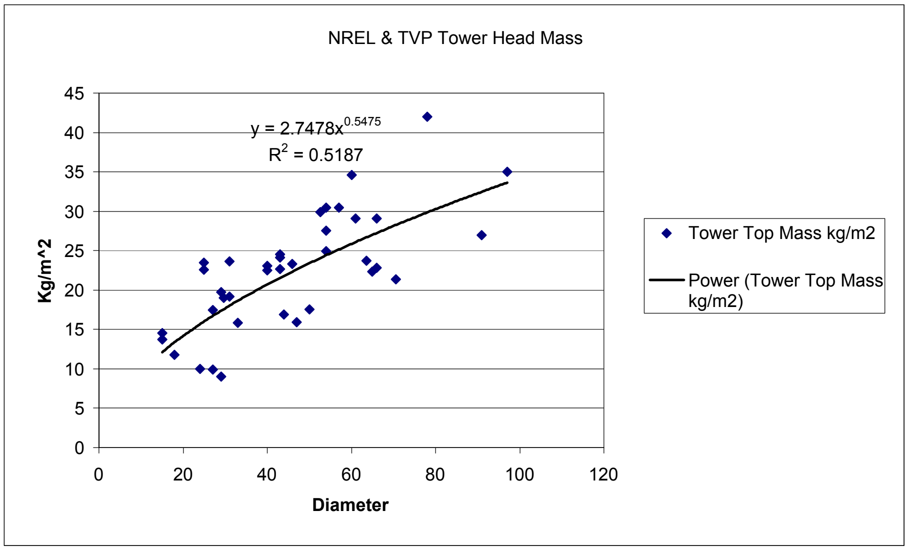
Appendix A
WindPACT Turbine

summary of muli MW wind turbine properties

manufacturer	model	no of blades	hub type	up/downwind	rotor diameter	max power	hub height	max rpm	tip speed	power/swept area	power control	drive type	blade mass	hub mass	rotor mass	nacelle mass	head mass	tower rated mass	total tower mass	sweptarea	tower headmass	specific nacelle mass
					m	MW	m		m/s	kW/m^2			kg	kg	kg	kg	kg	kg/kw	kg	m^2	kg/m^2	kg/kw
Experimental Turbines																						
Boeing	Mod-2	2	teeter	up	91.4	2.5	61	17	81	0.38	ailerons	var spd			89811	79378	169200		115700	6561		
Boeng	Mod 5B	2	teeter	up	97.5	3.2	61	17	87	0.43	ptch tip				141975	114760	256800	80	159600	7466	34	36
Ham Std	WTS-4	2	teeter	up																		
GE	Mod-5A	2			122	7.3		16.8	107	0.62										11690		
Aerodyn	multibrid	3	rigid	up	100	5		16.2	85	0.64	stall	hybrid	11000	12000	45000	110000	155000	31		7854	20	22
Existing/Past Turbines																						
Nordex	N80/2500	3	rigid	up	80	2.5	80			0.50					48300	82700	131000	52	179300	5027	26	33
Nordex	N 54/1000	3	rigid		54	1	70	22	62	0.44					19000	46000	65000	65	107000	2290	28	46
Nordex	N60/1300	3			60	1.3	69			0.46					18900	49200	68100	52	104000	2827	24	38
Tacke		3	rigid	up	70.5	1.5				0.38										3904		
Tacke	TW 1.5	3	rigid	up	65	1.5	80	20	68	0.45	pitch	var spd (1.4:1)								3318		
Bonus		3	rigid	up	62	2				0.66										3019		
Dewind		3	rigid	up	62	1				0.33										3019		
HSW	1000/57	3			57	1.05	70	23	68	0.41	pitch	2-speed								2552		
Windtec		3	rigid	up	67	1.5				0.43										3526		
Kvaerner	WTS 80	2			80.5	3	80	21	88	0.59	pitch	var spd (1.5:1)								5090		
Vestas	V63	3	rigid	up	63	1.5	60	21	69	0.48	pitch	2 speed w/ 10% slip								3117	0	
Bonus	1 MW/54	3	rigid	up	54	1	60	22	62	0.44	active stall	2 speed					63000	63		2290	28	
Enercon	E-66	3	rigid	up	66	1.5	100	20	70	0.44	pitch	var spd (2.5:1)					99500	66		3421	29	
Micon	M2300	3	rigid	up	54	1	59	21	59	0.44	stall	2 speed					57000	57		2290	25	
Micon	NM900/52	3	rigid	up	52	0.9				0.42			2720	11800	19960	21800	41760	46		2124	20	24
Nedwind	NW 53/2/1000-240	2	rigid?	up	52.6	1	70	25	68	0.46	active stall	2 speed					65000	65		2173	30	
Nedwind	NW 55/2/1000-240	2	rigid?	up	55	1	70	25	71	0.42	active stall	2 speed								2376	0	
Nordank	NTK 1500/60	3	rigid	up	60	1.5	68	19	60	0.53	stall	constant					98000	65		2827	35	
Autoflug	A1200	2	?	up	61	1.2	60	21	66	0.41	pitch	2 speed					85000	71		2922	29	
Zond	Z80	3	rigid	up	80	1.8	85	20	84	0.36	pitch	var spd								5027	0	
Zond	TZ-1.5	3	rigid	up	70.5	1.5	80			0.38	pitch	var spd	5600	15500	32300	51000	83300	56	109000	3904	21	34
Zond	Z-750	3			50	0.75	50			0.38		var spd	3780	4989	16329	23660	39989	53	58740	1963	20	32
Nordic	1000	2			53	1	58	25	69	0.45	stall	2 speed								2206	0	0
TVP Turbines																						
Vestas - BS	V66	3	rigid	up	66	1.65	80	19	66	0.48	pitch	2 speed w/ 10% slip	3850	10250	21800	56000	78000	47	145000	3421	23	34
Vestas -BS	V47	3	rigid	up	47	0.66	65	28.5	70	0.38	pitch	constant w/ 10% slip	1450	2850	7200	20400	27600	42	50700	1735	16	31
Zond - CSW	Z-40 A	3	rigid	up	40	0.5	40			0.40		constant	1815	3450	8895	16874	25769	52		1257	21	34
Zond - GMP	Z-40 FS	3	rigid	up	40	0.55	65			0.44		constant	1610	4392	9222	19050	28272	51		1257	22	35
Zond - Iowa	Z-50	3	rigid	up	50	0.75	50	19 - 32.2		0.38		var spd	3540		12250	22220	34470	46		1963	18	30
AOC - KEA	AOC 15/50	3	rigid	down	15	0.066	26.5			0.37	stall/tip	constant			500	1920	2420	37		177	14	29
Zond - NE	Z-50	3	rigid	up	50	0.75	65			0.38		var spd	3540		12250	22220	34470	46		1963	18	30
Tacke - WS	TW 600-3-CWM	3	rigid	up	46	0.6	60			0.36		var spd	1900	3400	9100	29600	38700	65		1662	23	49
									AVG	0.44												

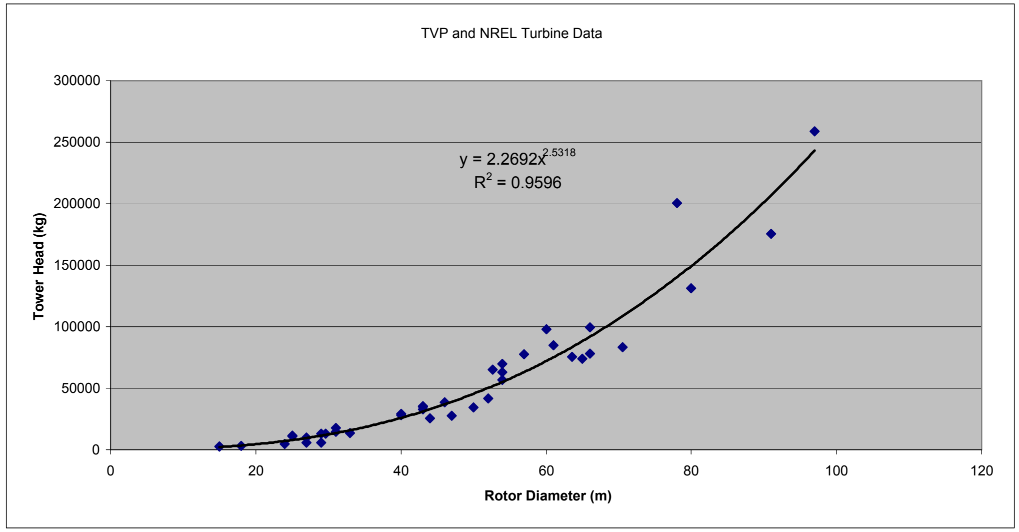
Data combined from Wind Energy Vol1 No. 2, Dec 1998 and TVP Turbine data from Page A-1.

Rotor Diam (m)	Tower Top Mass kg/m^2
33	15.8
61	29.1
18	11.8
27	17.5
78	42
91	27
97	35
40	23.1
66	29.1
57	30.5
25	23.5
65	22.3
29	19.7
44	16.9
52.6	29.9
29	9
24	10
27	9.9
54	27.5
15	14.5
31	19.2
43	24.1
54	24.9
29.6	19
43	24.5
54	30.5
60	34.6
31	23.6
43	22.7
63.6	23.7
25	22.6
15	13.7
40	22.5
46	23.3
47	15.9
50	17.6
66	22.8
70.5	21.3



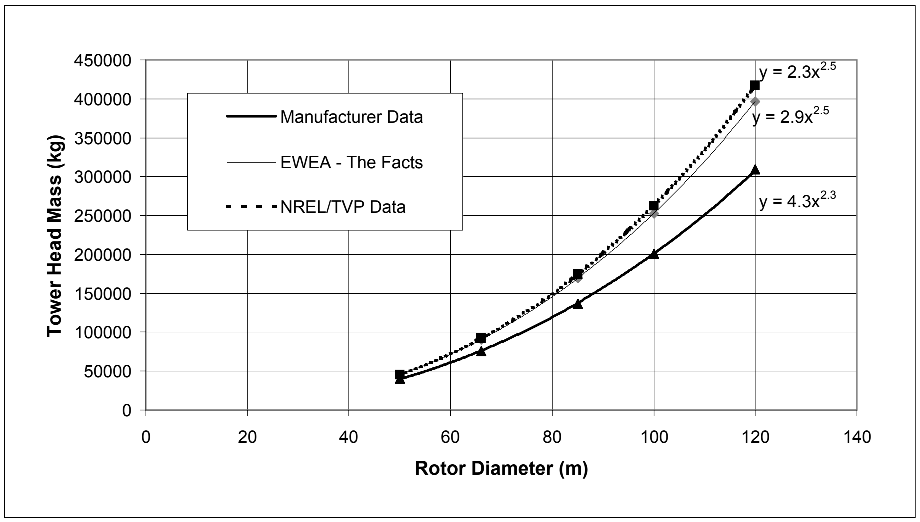
Data From Page A-2 Converted to Tower Head Mass

Rotor Diam (m)	Tower Top Mass/swept area (kg/m^2)	Tower Head Mass (kg)
33	15.8	13514
61	29.1	85044
18	11.8	3003
27	17.5	10020
78	42.0	200691
91	27.0	175605
97	35.0	258643
40	23.1	29028
66	29.1	99557
57	30.5	77829
25	23.5	11536
65	22.3	73998
29	19.7	13012
44	16.9	25697
52.6	29.9	64973
29	9.0	5945
24	10.0	4524
27	9.9	5668
54	27.5	62981
15	14.5	2562
31	19.2	14492
43	24.1	34998
54	24.9	57027
29.6	19.0	13075
43	24.5	35579
54	30.5	69852
60	34.6	97829
31	23.6	17813
43	22.7	32965
63.6	23.7	75293
25	22.6	11094
15	13.7	2420
40	22.5	28272
46	23.3	38700
47	15.9	27600
50	17.6	34470
66	22.8	78000
70.5	21.3	83300
80	26.1	131000
52	19.7	41760



EC Equations Source: European Commission Directorate - General for Energy, Wind Energy - The Facts, Volume 1 - Technology (Appendix), EWEA Web Site, 1998

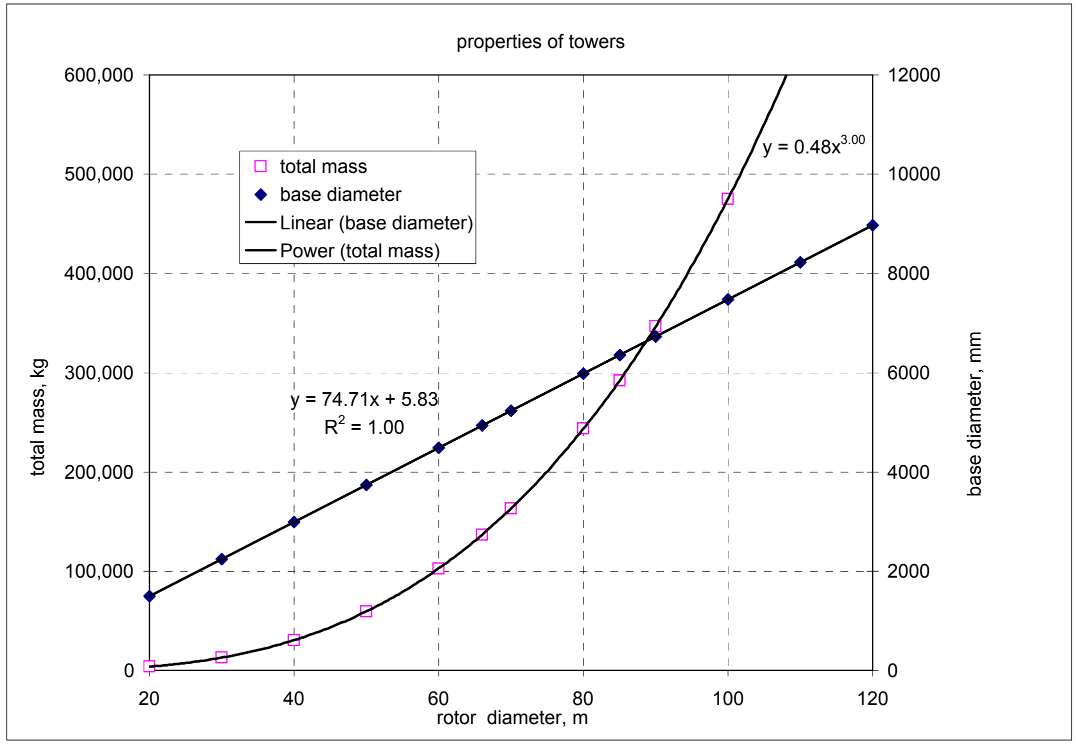
Rotor Dia (m)	EWEA - The Facts				NREL and TVP Head Mass Equation	Manufacturer Based Data			
	Nacelle Mass Equation Fig 4.6.3	3 x Blade Mass Equation (Fig 4.5.2)	Manufactuer Hub Mass Equation	Total Head Mass		3 x Blade Scaling Study Mass Equation	Manufactuer Hub Mass	Manufactuer Nacelle Mass	Total Head Mass
	kg	kg	kg	kg	kg	kg	kg	kg	kg
50	31081	8819	5723	45623	45424	6150	5723	28179	40052
66	60517	18303	11702	90522	91739	13639	11702	50622	75963
85	111065	35604	22457	169126	174075	28184	22457	86333	136974
100	164049	54591	34136	252776	262685	44926	34136	121648	200709
120	254102	88180	54604	396885	416779	75800	54604	178721	309125



Tower design prepared by D Malcolm, May 2000
design of free-standing tower prepared by D Malcolm, May 2000
Revised on July 27, 2000 by K. Smith/D Malcolm

Assumptions:

1. IEC class 2 wind regime. Ve50 wind on tower, Ve50 wind on non-pitched blades.
2. Linear taper between top and base.
3. Peak load governs, tower dia / thickness for CSA S16.1 class 3 (non compact)
4. Assumed control for pitchable blades has failed in operational position.
5. Fatigue and dynamics are not included, however, as a compromise the Ve50 wind speed is used inplace of the Ve1 value.
6. Total characteristic base mt has been calculated to be provided as an input to the foundation design. It is assumed that the foundation design will apply a load factor to this value, therefore the tower load factor has been removed.
7. Although IEC allows modification to the load factor under fault assumptions, no modification has been used to allow compensation for fatigue and dynamics.



input

Ve50 wind speed =	59.5	m/s
Ve1 wind speed =	59.5	m/s
upper twr dia fraction	0.5	* base diameter
max dia/thickness=	66000	/Fy
material yield=Fy=	300	Mpa
	220	
material density=	7850	kg/m^3
twr ht / rotor diam =	1.3	
flapwise Cd =	1.8	
rotor solidity =	0.05	
air density =	1.225	kg/m^3
load factor =	1.35	
material factor =	1.1	

						initial design				final design									
rotor diam	tower height	design rotor thrust, Ve1	design base mt from thrust	design stress	diam/ thickness ratio	req'd section modulus	req'd base diameter	design drag on tower	des base mt	total design base mt	total characteristics base mt	req'd section modulus	req'd base diameter	thickness at base	sect area at base	diameter at top	thickness at top	sect area at top	total mass
m	m	kN	kN m	Mpa		mm^3	mm	kN	kN m	kN m	kN m	mm^3	mm	mm	mm^2	mm	mm		kg
20	26.0	82.8	2152	272.7	220.0	7.89E+06	1293	103.4	1194	3346	2479	1.23E+07	1498	6.81	3.20E+04	749	3.40	8.01E+03	3816
30	39.0	186.2	7263	272.7	220.0	2.66E+07	1939	232.5	4029	11292	8365	4.14E+07	2246	10.21	7.20E+04	1123	5.10	1.80E+04	12866
40	52.0	331.1	17216	272.7	220.0	6.31E+07	2585	413.1	9548	26764	19825	9.81E+07	2994	13.61	1.28E+05	1497	6.80	3.20E+04	30479
50	65.0	517.3	33625	272.7	220.0	1.23E+08	3230	645.4	18644	52269	38718	1.92E+08	3741	17.01	2.00E+05	1871	8.50	5.00E+04	59499
60	78.0	744.9	58104	272.7	220.0	2.13E+08	3876	929.2	32212	90315	66900	3.31E+08	4489	20.40	2.88E+05	2244	10.20	7.19E+04	102772
66	85.8	901.4	77336	272.7	220.0	2.84E+08	4263	1124.2	42870	120206	89041	4.41E+08	4937	22.44	3.48E+05	2469	11.22	8.70E+04	136760
70	91.0	1013.9	92266	272.7	220.0	3.38E+08	4521	1264.5	51143	143410	106229	5.26E+08	5236	23.80	3.92E+05	2618	11.90	9.79E+04	163141
80	104.0	1324.3	137727	272.7	220.0	5.05E+08	5166	1651.4	76332	214059	158562	7.85E+08	5983	27.20	5.11E+05	2992	13.60	1.28E+05	243450
85	110.5	1495.0	165199	272.7	220.0	6.06E+08	5489	1864.2	91551	256750	190185	9.41E+08	6357	28.89	5.77E+05	3178	14.45	1.44E+05	291970
90	117.0	1676.1	196100	272.7	220.0	7.19E+08	5811	2089.8	108670	304770	225756	1.12E+09	6730	30.59	6.47E+05	3365	15.30	1.62E+05	346540
100	130.0	2069.2	268998	272.7	220.0	9.86E+08	6456	2579.7	149052	418050	309667	1.53E+09	7477	33.99	7.98E+05	3739	16.99	2.00E+05	475252
110	143.0	2503.8	358037	272.7	220.0	1.31E+09	7101	3121.2	198369	556406	412153	2.04E+09	8224	37.38	9.66E+05	4112	18.69	2.41E+05	632425
120	156.0	2979.7	464829	272.7	220.0	1.70E+09	7746	3714.2	257515	722344	535070	2.65E+09	8971	40.78	1.15E+06	4485	20.39	2.87E+05	820900
130	169.0	3497.0	590989	272.7	220.0	2.17E+09	8391	4358.6	327382	918371	680275	3.37E+09	9717	44.17	1.35E+06	4859	22.08	3.37E+05	1043515
140	182.0	4055.7	738131	272.7	220.0	2.71E+09	9036	5054.6	408861	1146993	849624	4.21E+09	10464	47.56	1.56E+06	5232	23.78	3.91E+05	1303109
150	195.0	4655.7	907869	272.7	220.0	3.33E+09	9680	5802.1	502847	1410716	1044975	5.17E+09	11211	50.96	1.79E+06	5605	25.48	4.49E+05	1602520
160	208.0	5297.2	1101817	272.7	220.0	4.04E+09	10325	6601.1	610231	1712048	1268183	6.28E+09	11957	54.35	2.04E+06	5979	27.18	5.10E+05	1944585
170	221.0	5980.0	1321589	272.7	220.0	4.85E+09	10970	7451.5	731904	2053493	1521106	7.53E+09	12704	57.74	2.30E+06	6352	28.87	5.76E+05	2332141

Manufacturer	Model	Rotor Diameter	Actual tower mass	GEC Tower Mass
		m	kg	kg
Nordex	N80/2500	80	179300	146022
Zond	TZ-1.5	70.5	109000	127598
Vestas - BS	V66	66	145000	119119
Vestas -BS	V47	47	50700	55906
Zond	Z-750	50	58740	35687
Nordex	N 54/1000	54	107000	74516
Nordex	N60/1300	60	104000	80757

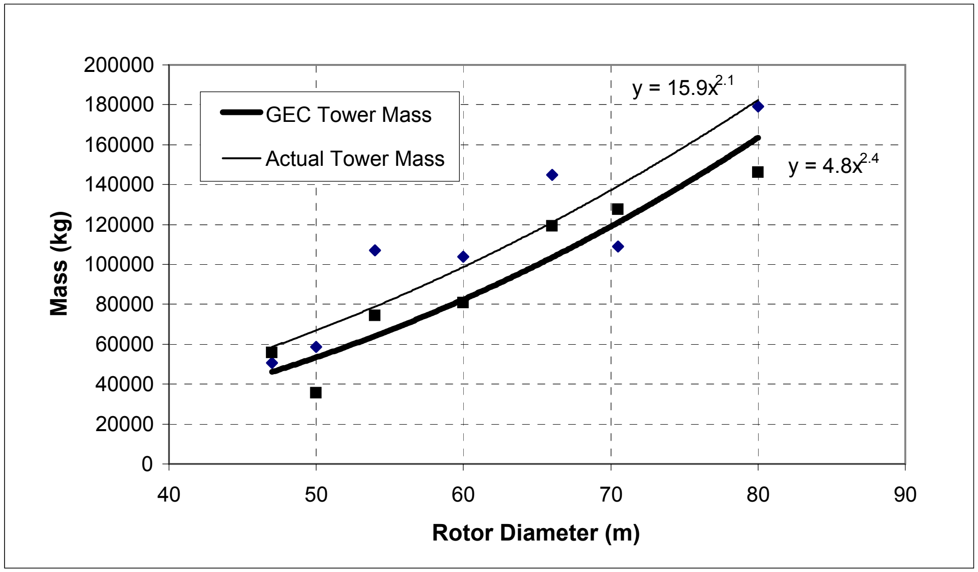
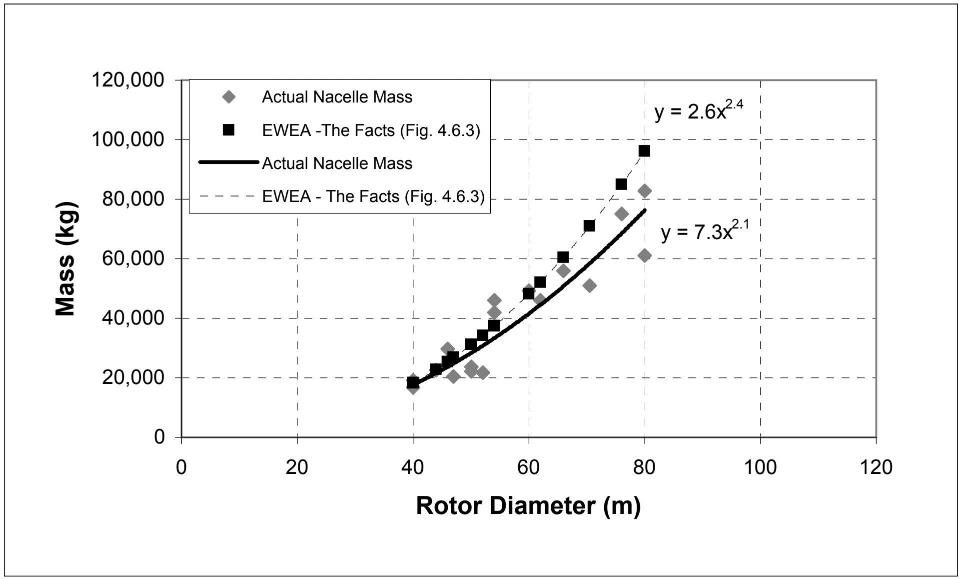
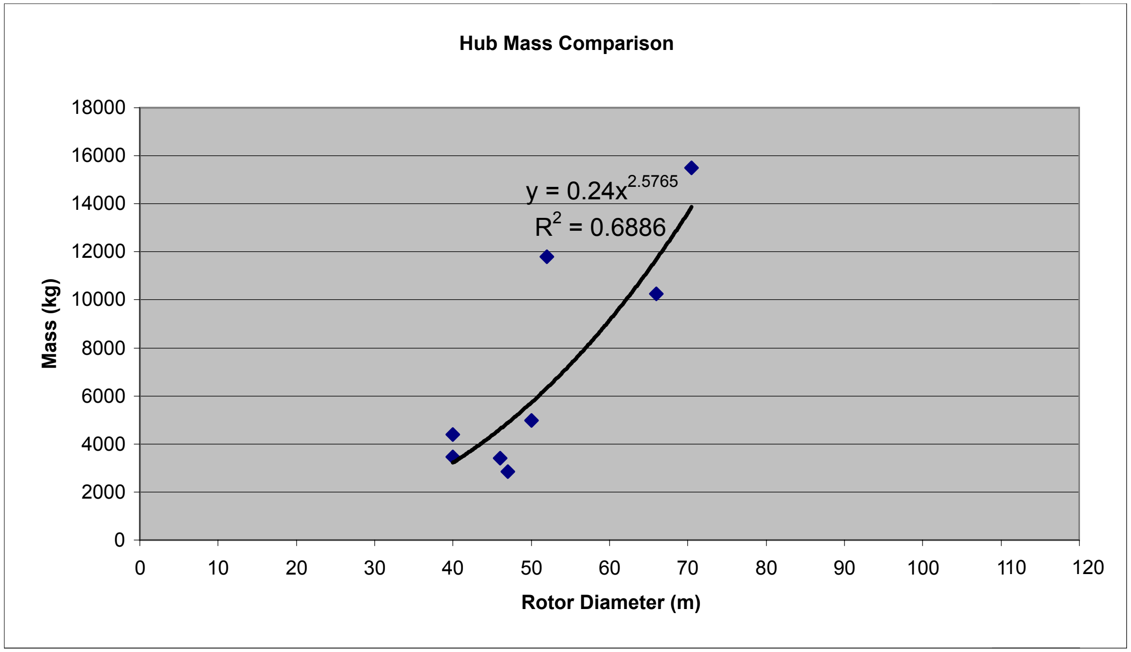


Figure 2-4

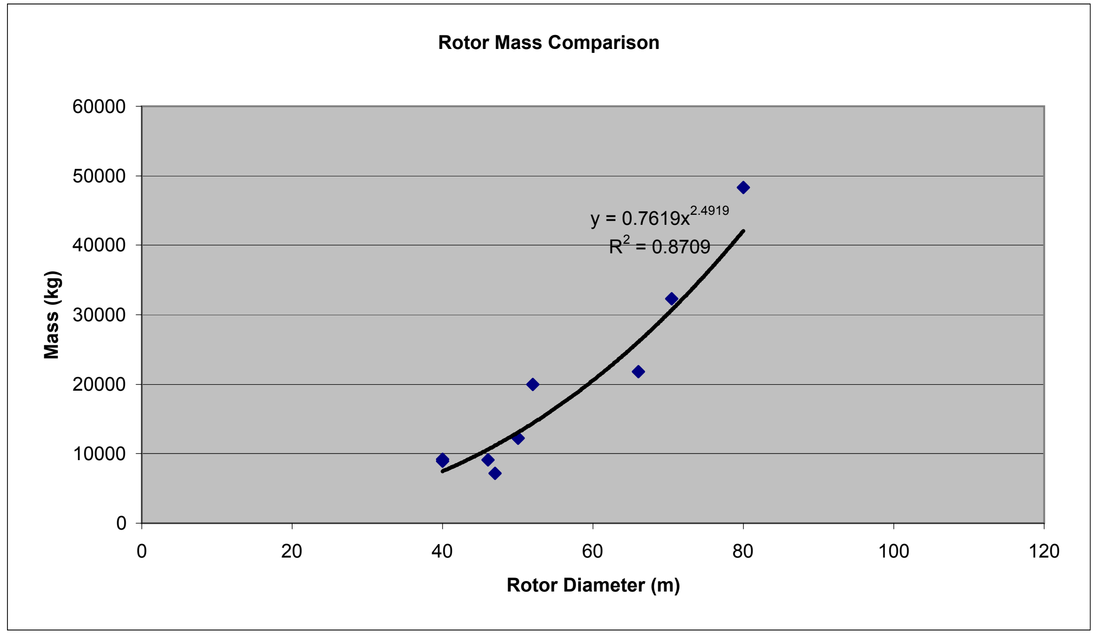
Manufacturer	Model	Rotor Diameter	Nacelle Mass	EWEA - The Facts (Fig 4.6.3)
		m	kg	kg
Nordex	N80/2500	80	82700	96026
Micon	NM900/52	52	21800	34149
Zond	TZ-1.5	70.5	51000	70897
Vestas - BS	V66	66	56000	60517
Vestas -BS	V47	47	20400	26792
Zond - CSW	Z-40 A	40	16874	18194
Zond - GMP	Z-40 FS	40	19050	18194
Zond - Iowa	Z-50	50	22220	31081
Tacke - WS	TW 600-3-CWM	46	29600	25444
Zond	Z-750	50	23660	31081
Nordex	N 54/1000	54	46000	37387
Nordex	N60/1300	60	49200	48143
Bonus	2MW	76	75000	84904
Bonus	1.3MW	62	46000	52085
Bonus	1MW	54	42000	37387
Bonus	600kW	44	22500	22870
Vestas	2MW	80	61000	96026
Boeing	Mod 5B	97.5	114760	154378
Boeing	Mod 2	91.4	79378	132204



manufacturer	model	rotor diameter m	hub mass kg
Micon	NM900/52	52	11800
Zond	TZ-1.5	70.5	15500
Vestas - BS	V66	66	10250
Vestas -BS	V47	47	2850
Zond - CSW	Z-40 A	40	3450
Zond - GMP	Z-40 FS	40	4392
Tacke - WS	TW 600-3-CWM	46	3400
Zond	Z-750	50	4989



manufacturer	model	rotor diameter m	rotor mass kg
Nordex	N80/2500	80	48300
Micon	NM900/52	52	19960
Zond	TZ-1.5	70.5	32300
Vestas - BS	V66	66	21800
Vestas -BS	V47	47	7200
Zond - CSW	Z-40 A	40	8895
Zond - GMP	Z-40 FS	40	9222
Zond - Iowa	Z-50	50	12250
Zond - NE	Z-50	50	12250
Tacke - WS	TW 600-3-CWM	46	9100



All Data for $TSR_{Design} = 7$, $C_{Max} = 8\%$ R, no parasitic weight

Rating	R	L	t/c = 27 % at max. chord				t/c = 33 % at max. chord		EWEA The Facts Fig 4.5.2	EWEA The Facts Fig 4.5.2
(MW)	(m)	(m)	W (kg)	W (10^3 kg)	Grav / Trq	Cap. Fac.	W (kg)	W (10^3 kg)	W (kg)	W (10^3kg)
0.75	23.3	22.1	1851	1.85	0.87	1.76	1725	1.73	2443	2.44
1.50	32.9	31.3	5017	5.02	1.18	1.39	4651	4.65	6052	6.05
2.00	38.0	36.1	7597	7.60	1.34	1.26	7029	7.03	8842	8.84
2.30	40.8	38.8	9284	9.28	1.43	1.20	8580	8.58	10660	10.66
3.00	46.6	44.3	13629	13.63	1.61	1.08	12571	12.57	15120	15.12
4.00	53.8	51.1	20685	20.69	1.83	0.97	19057	19.06	22063	22.06
5.00	60.2	57.2	28626	28.63	2.02	0.89	26334	26.33	29652	29.65

Commercial Blade Data:

L	R	Rating	W	W	Blade / Turbine
(m)	(m)	(MW)	(kg)	(10^3 kg)	
21.0	22.1	675	2100	2.10	LM
21.5	22.6	708	2650	2.65	LM
22.1	23.3	748	1600	1.60	LM
22.3	23.5	763	1450	1.45	V47
23.3	24.5	831	2800	2.80	LM
23.8	25.0	864	3540	3.54	Z-50
24.1	25.4	889	2400	2.40	LM
24.1	25.4	889	2600	2.60	LM
26.1	27.5	1043	4000	4.00	LM
31.4	33.0	1505	3850	3.85	V66
33.3	35.0	1692	5600	5.60	TZ-1.6
33.8	35.6	1749	7800	7.80	LM
34.0	35.8	1770	5600	5.60	LM
37.3	39.3	2130	6035	6.04	LM
38.8	40.8	2305	8500	8.50	LM

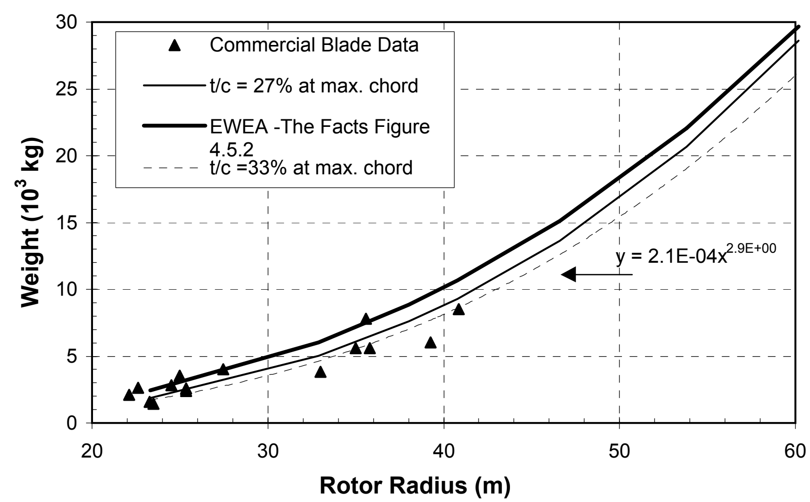


Figure 2-1

Appendix B
Scenario Summary

		Summary				
		750	1500	2500	3500	5000
	Rotor Diameter (m)	50	66	85	100	120
	Calculated Power (kW)	864	1505	2497	3456	4976
Scenario 1: Baseline - all components pre-assembled to maximum extent possible.	Low	$48.73	$59.06	$550.70	$717.75	$785.22
	Middle	$64.58	$77.38	$601.97	$776.42	$969.63
	High	$109.90	$151.91	$679.35	$936.06	$1,035.05
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (BOLTED).	Low	$48.73	$70.00	$84.79	$124.66	$167.93
	Middle	$64.58	$89.48	$106.73	$148.61	$319.21
	High	$109.90	$165.57	$186.95	$311.87	$388.57
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (MANUAL WELDING).	Low	$48.73	$79.71	$102.27	$167.91	$244.04
	Middle	$64.58	$100.34	$126.16	$196.67	$403.77
	High	$109.90	$178.15	$209.29	$367.13	$485.81
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (SEMI-AUTOMATED WELDING).	Low	$48.73	$75.37	$94.21	$146.97	$207.77
	Middle	$64.58	$95.52	$117.20	$173.40	$363.48
	High	$109.90	$172.61	$198.98	$340.37	$439.47
Scenario 3: Gearbox and generator installed in nacelle atop tower. Rotors assembled in air. 2.5+ MW turbine towers require field assembly.	Low	$48.73	$70.00	$88.67	$130.33	$169.31
	Middle	$64.58	$89.48	$111.31	$156.56	$318.76
	High	$109.90	$165.57	$190.38	$317.10	$390.45

Notes:

1) Costs presented on this page correspond to combined Transportation, Assembly, and Crane costs.

2) See pages B-2 to B-4 for corresponding summaries.

		Transportation				
		750	1500	2500	3500	5000
	Rotor Diameter (m)	50	66	85	100	120
	Calculated Power (kW)	864	1505	2497	3456	4976
Scenario 1: Baseline - all components pre-assembled to maximum extent possible. [1]	U.S. Sourced - Short Haul	$26.25	$35.91	$528.08	$691.42	$754.83
	U.S. Sourced - Long Haul	$32.71	$43.99	$567.92	$737.94	$923.68
	European Sourced	$76.68	$117.08	$643.52	$895.71	$985.19
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (BOLTED). [2]	U.S. Sourced - Short Haul	$26.25	$35.91	$44.55	$75.91	$113.21
	U.S. Sourced - Long Haul	$32.71	$43.99	$53.02	$85.16	$246.13
	European Sourced	$76.68	$117.08	$128.62	$242.92	$307.65
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (MANUAL WELDING). [2]	U.S. Sourced - Short Haul	$26.25	$35.91	$44.55	$75.91	$113.21
	U.S. Sourced - Long Haul	$32.71	$43.99	$53.02	$85.16	$246.13
	European Sourced	$76.68	$117.08	$128.62	$242.92	$307.65
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (SEMI-AUTOMATED WELDING). [2]	U.S. Sourced - Short Haul	$26.25	$35.91	$44.55	$75.91	$113.21
	U.S. Sourced - Long Haul	$32.71	$43.99	$53.02	$85.16	$246.13
	European Sourced	$76.68	$117.08	$128.62	$242.92	$307.65
Scenario 3: Gearbox and generator installed in nacelle atop tower. Rotors assembled in air. 2.5+ MW turbine towers require field assembly. [3]	U.S. Sourced - Short Haul	$26.25	$35.91	$45.76	$78.28	$111.38
	U.S. Sourced - Long Haul	$32.71	$43.99	$54.78	$89.79	$242.44
	European Sourced	$76.68	$117.08	$129.34	$244.77	$306.20

Notes:

[1] See cost component summaries on pages C-1 and C-2.

[2] See cost component summaries on pages C-3 and C-4.

[3] See cost component summaries on pages C-5 and C-6.

		Assembly				
		750	1500	2500	3500	5000
	Rotor Diameter (m)	50	66	85	100	120
	Calculated Power (kW)	864	1505	2497	3456	4976
Scenario 1: Baseline - all components pre-assembled to maximum extent possible.	Minimum (See Appendix I-2)	$15.11	$10.86	$11.35	$9.68	$11.85
	Average (See Appendix I-1)	$23.55	$16.98	$17.70	$15.60	$19.05
	Maximum (See Appendix I-3)	$24.57	$17.79	$18.67	$16.50	$20.73
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (BOLTED).	Minimum (See Appendix J-2)	$15.11	$19.32	$25.89	$27.12	$30.42
	Average (See Appendix J-1)	$23.55	$26.49	$34.00	$35.12	$39.85
	Maximum (See Appendix J-3)	$24.57	$28.72	$37.39	$38.94	$44.62
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (MANUAL WELDING).	Minimum (See Appendix K-2)	$15.11	$26.59	$38.62	$57.03	$82.33
	Average (See Appendix K-1)	$23.55	$34.57	$48.16	$68.36	$97.53
	Maximum (See Appendix K-3)	$24.57	$38.02	$53.67	$77.16	$110.96
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (SEMI-AUTOMATED WELDING).	Minimum (See Appendix L-2)	$15.11	$23.27	$32.45	$42.11	$57.06
	Average (See Appendix L-1)	$23.55	$30.89	$41.30	$51.78	$69.45
	Maximum (See Appendix L-3)	$24.57	$33.78	$45.79	$58.10	$78.66
Scenario 3: Gearbox and generator installed in nacelle atop tower. Rotors assembled in air. 2.5+ MW turbine towers require field assembly.	Minimum (See Appendix M-2)	$15.11	$19.32	$27.18	$28.53	$31.69
	Average (See Appendix M-1)	$23.55	$26.49	$35.29	$36.53	$41.12
	Maximum (See Appendix M-3)	$24.57	$28.72	$38.68	$40.35	$45.89

Notes:

1) Assembly Costs for 750 kW turbine presented as baseline for current construction practices.

		Cranes				
		750	1500	2500	3500	5000
	Rotor Diameter (m)	50	66	85	100	120
	Calculated Power (kW)	864	1505	2497	3456	4976
Scenario 1: Baseline - all components pre-assembled to maximum extent possible. [1]	Minimum	$7.37	$12.29	$11.27	$16.65	$18.53
	Average	$8.33	$16.41	$16.35	$22.88	$26.90
	Maximum	$8.64	$17.03	$17.15	$23.86	$29.12
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (BOLTED). [2],[3]	Minimum	$7.37	$14.77	$14.35	$21.63	$24.30
	Average	$8.33	$19.00	$19.71	$28.32	$33.23
	Maximum	$8.64	$19.76	$20.94	$30.00	$36.30
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (MANUAL WELDING). [2],[4]	Minimum	$7.37	$17.21	$19.10	$34.97	$48.49
	Average	$8.33	$21.77	$24.99	$43.15	$60.11
	Maximum	$8.64	$23.05	$27.00	$47.05	$67.21
Scenario 2: Scenario 1 except rotors assembled in air and 2.5+ MW turbine towers require field assembly (SEMI-AUTOMATED WELDING). [2],[5]	Minimum	$7.37	$16.19	$17.21	$28.95	$37.50
	Average	$8.33	$20.64	$22.88	$36.45	$47.89
	Maximum	$8.64	$21.75	$24.58	$39.35	$53.17
Scenario 3: Gearbox and generator installed in nacelle atop tower. Rotors assembled in air. 2.5+ MW turbine towers require field assembly. [6]	Minimum	$7.37	$14.77	$15.73	$23.53	$26.24
	Average	$8.33	$19.00	$21.23	$30.24	$35.20
	Maximum	$8.64	$19.76	$22.36	$31.98	$38.36

Notes:

[1] Scenario 1 crane costs detailed on pages I-4 to I-7.

Scenario 1), and a second crane deployed for tower fabrication. The tower fabrication crane costs are dependent on the

[3] Bolted crane costs are detailed on page J-8.

[4] Manual welding crane costs are detailed on page K-8.

[5] Automated welding crane costs are detailed on page L-8.

[6] Tower fabrication crane costs using the bolting fabrication technique (from page J-8) are added to the assembly crane costs (from page M-8).

Appendix C
Transport Summary

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				TRUCK TRANSPORT COSTS					STEERABLE DOLLY TRANSPORT COSTS				
2				Detailed Costs in Appendix D					Detailed Costs in Appendix E				
3				Turbines					Turbines				
4	**Component**	**Origin**	**Destination**	750	1500	2500	3500	5000	750	1500	2500	3500	5000
5	Blades	Port of Houston, TX	South Dakota	$7.14	$6.76	$7.03	$11.56						
6		Gainesville, TX	South Dakota	$6.40	$6.06	$6.30	$10.37						
7		Port of Duluth, MN	South Dakota	$3.47	$3.29	$4.89	$7.42	$7.29					
8		Grand Forks, ND	South Dakota	$2.91	$2.76	$4.10	$5.51	$5.31					
9		Gainesville, TX	Port of Houston					$2.19					
10		Port of Houston	Sioux City, IA										
11		Sioux City, IA	South Dakota					$1.66					
12		Europe	Port of Houston, TX/Port of Duluth, MN										
13													
14	Hubs	Port of Houston, TX	South Dakota	$2.27	$2.23	$2.69	$2.43	$2.14					
15		Port of Duluth, MN	South Dakota	$1.74	$1.99	$1.44	$1.30	$1.15					
16		Chicago, IL	South Dakota	$2.19	$2.52	$1.82	$1.65	$1.45					
17		Tehachapi, CA	South Dakota	$2.98	$2.93	$3.53	$3.19	$2.81					
18		Europe	Port of Houston, TX/Port of Duluth, MN										
19													
20	Nacelle	Port of Houston, TX	South Dakota	$5.19	$5.59	$4.94							
21		Port of Duluth, MN	South Dakota	$3.82	$2.79	$2.64					$92.12	$70.90	$52.25
22		Chicago, IL	South Dakota	$5.26	$4.03	$3.34					$95.28	$74.33	$55.42
23		Tehachapi, CA	South Dakota	$6.81	$7.32	$6.48					$149.59	$118.72	$89.83
24		Port of Houston	Sioux City, IA										
25		Europe	Port of Houston, TX/Port of Duluth, MN										
26		Sioux City, IA	South Dakota								$65.08	$48.83	$35.17
27													
28	Towers	Canutillo, TX (El Paso)	South Dakota	$16.52	$27.68	$9.12	$3.54						
29		Dallas, TX	South Dakota	$16.66	$27.90	$9.20	$3.57						
30		Shreveport, LA	South Dakota	$15.89	$26.61	$8.77	$3.40						
31		Europe	Port of Houston, TX/Port of Duluth, MN										
32		Canutillo, TX (El Paso)	Port of Houston							$125.55	$227.09	$273.46	$265.86
33		Dallas, TX	Port of Houston							$107.95	$195.25	$235.12	$228.58
34		Shreveport, LA	Port of Houston							$107.62	$194.65	$234.39	$227.88
35		Port of Houston	Sioux City, IA										
36		Sioux City, IA	South Dakota							$107.95	$195.25	$235.12	$228.58

			Turbine Rating:	**750 kW**	**1500 kW**	**2500 kW**	**3500 kW**	**5000 kW**
38			**Turbine Rating:**	**750 kW**	**1500 kW**	**2500 kW**	**3500 kW**	**5000 kW**
39			**Notes:**	**I**	**II**	**III**	**IV**	**V**
40	**Summary**	**U.S. Source - Short Haul**		**$26.25**	**$35.91**	**$528.08**	**$691.42**	**$754.83**
41		**U.S. Source - Long Haul**		**$32.71**	**$43.99**	**$567.92**	**$737.94**	**$923.68**
42		**European Sourced**		**$76.68**	**$117.08**	**$643.52**	**$895.71**	**$985.19**

Notes:

I
U.S. Source - Short Haul costs = Blades (D8) + Hubs (D16) + Nacelle (D22) + Towers (D30)
U.S. Source - Long Haul costs = Blades (D6) + Hubs (D17) + Nacelle (D23) + Towers (D28)
European Sourced = Blades (D7+X12) + Hubs (D15+X18) + Nacelle (D21+X25) + Towers (D28)

II
U.S. Source - Short Haul costs = Blades (E8) + Hubs (E16) + Nacelle (E22) + Towers (E30)
U.S. Source - Long Haul costs = Blades (E6) + Hubs (E17) + Nacelle (E23) + Towers (E28)
European Sourced = Blades (E7+Y12) + Hubs (E15+Y18) + Nacelle (E21+Y25) + Towers (E28)

III
U.S. Source - Short Haul costs = Blades (F8) + Hubs (F16) + Nacelle (F22) + Towers (F30+K34+K36+U35)
U.S. Source - Long Haul costs = Blades (F6) + Hubs (F17) + Nacelle (F23) + Towers (F28+K32+K36+U35)
European Sourced = Blades (F7+Z12) + Hubs (F15+Z18) + Nacelle (F21+Z25) + Towers (F28+K32+K36+U35)

IV
U.S. Source - Short Haul costs = Blades (G8) + Hubs (G16) + Nacelle (Q22) + Towers (G30+L34+L36+V35)
U.S. Source - Long Haul costs = Blades (G6) + Hubs (G17) + Nacelle (Q23) + Towers (G28+L32+L36+V35)
European Sourced = Blades (G7+AA12) + Hubs (G15+AA18) + Nacelle (Q21+AA25) + Towers (G28+L32+L36+V35)

V
U.S. Source - Short Haul costs = Blades (H8) + Hubs (H16) + Nacelle (M22) + Towers (H30+M34+M36+W35)
U.S. Source - Long Haul costs = Blades (H9+H11+W10) + Hubs (H17) + Nacelle (M23) + Towers (H28+M32+M36+W35)
European Sourced = Blades (H7+AB12) + Hubs (H15+AB18) + Nacelle (M21+AB25) + Towers (H28+M32+M36+W35)

	A	B	C	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1				RAIL TRANSPORT COSTS					BARGE TRANSPORT COSTS					OCEAN SHIPPING TRANSPORT COSTS				
2				Detailed Costs in Appendix F					Detailed Costs in Appendix G					Detailed Costs in Appendix H				
3				Turbines					Turbines					Turbines				
4	Component	Origin	Destination	750	1500	2500	3500	5000	750	1500	2500	3500	5000	750	1500	2500	3500	5000
5	Blades	Port of Houston, TX	South Dakota															
6		Gainesville, TX	South Dakota															
7		Port of Duluth, MN	South Dakota															
8		Grand Forks, ND	South Dakota															
9		Gainesville, TX	Port of Houston															
10		Port of Houston	Sioux City, IA										$96.56					
11		Sioux City, IA	South Dakota															
12		Europe	Port of Houston, TX/Port of Duluth, MN											$32.92	$57.00	$62.12	$146.49	$175.25
13																		
14	Hubs	Port of Houston, TX	South Dakota															
15		Port of Duluth, MN	South Dakota															
16		Chicago, IL	South Dakota															
17		Tehachapi, CA	South Dakota															
18		Europe	Port of Houston, TX/Port of Duluth, MN											$2.59	$6.03	$4.78	$3.45	$3.36
19																		
20	Nacelle	Port of Houston, TX	South Dakota	$15.40	$9.76	$7.01	$21.60											
21		Port of Duluth, MN	South Dakota	$14.60	$8.91	$6.07	$20.59											
22		Chicago, IL	South Dakota	$14.85	$9.19	$6.37	$20.92											
23		Tehachapi, CA	South Dakota	$15.44	$10.22	$7.24	$21.84											
24		Port of Houston	Sioux City, IA								$44.66	$58.97	$44.32					
25		Europe	Port of Houston, TX/Port of Duluth, MN											$15.63	$18.31	$16.02	$13.89	$15.26
26		Sioux City, IA	South Dakota															
27																		
28	Towers	Canutillo, TX (El Paso)	South Dakota															
29		Dallas, TX	South Dakota															
30		Shreveport, LA	South Dakota															
31		Europe	Port of Houston, TX/Port of Duluth, MN											$482	$636	$819	$963	$1,156
32		Canutillo, TX (El Paso)	Port of Houston															
33		Dallas, TX	Port of Houston															
34		Shreveport, LA	Port of Houston															
35		Port of Houston	Sioux City, IA							$43.90	$120.15	$190.44	$236.19					
36		Sioux City, IA	South Dakota															

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				TRUCK TRANSPORT COSTS					STEERABLE DOLLY TRANSPORT COSTS				
2				Detailed Costs in Appendix D					Detailed Costs in Appendix E				
3				Turbines					Turbines				
4	**Component**	**Origin**	**Destination**	750	1500	2500	3500	5000	750	1500	2500	3500	5000
5	Blades	Port of Houston, TX	South Dakota	$7.14	$6.76	$7.03	$11.56						
6		Gainesville, TX	South Dakota	$6.40	$6.06	$6.30	$10.37						
7		Port of Duluth, MN	South Dakota	$3.47	$3.29	$4.89	$7.42	$7.29					
8		Grand Forks, ND	South Dakota	$2.91	$2.76	$4.10	$5.51	$5.31					
9		Gainesville, TX	Port of Houston					$2.19					
10		Port of Houston	Sioux City, IA										
11		Sioux City, IA	South Dakota					$1.66					
12		Europe	Port of Houston, TX/Port of Duluth, MN										
13													
14	Hubs	Port of Houston, TX	South Dakota	$2.27	$2.23	$2.69	$2.43	$2.14					
15		Port of Duluth, MN	South Dakota	$1.74	$1.99	$1.44	$1.30	$1.15					
16		Chicago, IL	South Dakota	$2.19	$2.52	$1.82	$1.65	$1.45					
17		Tehachapi, CA	South Dakota	$2.98	$2.93	$3.53	$3.19	$2.81					
18		Europe	Port of Houston, TX/Port of Duluth, MN										
19													
20	Nacelle	Port of Houston, TX	South Dakota	$5.19	$5.59	$4.94							
21		Port of Duluth, MN	South Dakota	$3.82	$2.79	$2.64					$92.12	$70.90	$52.25
22		Chicago, IL	South Dakota	$5.26	$4.03	$3.34					$95.28	$74.33	$55.42
23		Tehachapi, CA	South Dakota	$6.81	$7.32	$6.48					$149.59	$118.72	$89.83
24		Port of Houston	Sioux City, IA										
25		Europe	Port of Houston, TX/Port of Duluth, MN										
26		Sioux City, IA	South Dakota								$65.08	$48.83	$35.17
27													
28	Towers	Canutillo, TX (El Paso)	South Dakota	$16.52	$27.68	$36.71	$49.77	$53.09					
29		Dallas, TX	South Dakota	$16.66	$27.90	$37.01	$50.17	$53.52					
30		Shreveport, LA	South Dakota	$15.89	$26.61	$35.29	$47.84	$51.04					
31		Europe	Port of Houston, TX/Port of Duluth, MN										
32		Canutillo, TX (El Paso)	Port of Houston										
33		Dallas, TX	Port of Houston										
34		Shreveport, LA	Port of Houston										
35		Port of Houston	Sioux City, IA										
36		Sioux City, IA	South Dakota										
37													

38		**Turbine Rating:**	**750 kW**	**1500 kW**	**2500 kW**	**3500 kW**	**5000 kW**
39		**Notes:**	**I**	**II**	**III**	**IV**	**V**
40	**Summary**	**U.S. Source - Short Haul**	**$26.25**	**$35.91**	**$44.55**	**$75.91**	**$113.21**
41		**U.S. Source - Long Haul**	**$32.71**	**$43.99**	**$53.02**	**$85.16**	**$246.13**
42		**European Sourced**	**$76.68**	**$117.08**	**$128.62**	**$242.92**	**$307.65**

NP - Not Practical/Possible

Notes:

I
U.S. Source - Short Haul costs = Blades (D8) + Hubs (D16) + Nacelle (D22) + Towers (D30)
U.S. Source - Long Haul costs = Blades (D6) + Hubs (D17) + Nacelle (D23) + Towers (D28)
European Sourced = Blades (D7+X12) + Hubs (D15+X18) + Nacelle (D21+X25) + Towers (D28)

II
U.S. Source - Short Haul costs = Blades (E8) + Hubs (E16) + Nacelle (E22) + Towers (E30)
U.S. Source - Long Haul costs = Blades (E6) + Hubs (E17) + Nacelle (E23) + Towers (E28)
European Sourced = Blades (E7+Y12) + Hubs (E15+Y18) + Nacelle (E21+Y25) + Towers (E28)

III
U.S. Source - Short Haul costs = Blades (F8) + Hubs (F16) + Nacelle (F22) + Towers (F30)
U.S. Source - Long Haul costs = Blades (F6) + Hubs (F17) + Nacelle (F23) + Towers (F28)
European Sourced = Blades (F7+Z12) + Hubs (F15+Z18) + Nacelle (F21+Z25) + Towers (F28)

IV
U.S. Source - Short Haul costs = Blades (G8) + Hubs (G16) + Nacelle (Q22) + Towers (G30)
U.S. Source - Long Haul costs = Blades (G6) + Hubs (G17) + Nacelle (Q23) + Towers (G28)
European Sourced = Blades (G7+AA12) + Hubs (G15+AA18) + Nacelle (Q21+AA25) + Towers (G28)

V
U.S. Source - Short Haul costs = Blades (H8) + Hubs (H16) + Nacelle (M22) + Towers (H30)
U.S. Source - Long Haul costs = Blades (H9+H11+W10) + Hubs (H17) + Nacelle (M23) + Towers (H28)
European Sourced = Blades (H7+AB12) + Hubs (H15+AB18) + Nacelle (M21+AB25) + Towers (H28)

	A	B	C	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1				**RAIL TRANSPORT COSTS**					**BARGE TRANSPORT COSTS**					**OCEAN SHIPPING TRANSPORT COSTS**				
2				Detailed Costs in Appendix F					Detailed Costs in Appendix G					Detailed Costs in Appendix H				
3				Turbines					Turbines					Turbines				
4	**Component**	**Origin**	**Destination**	750	1500	2500	3500	5000	750	1500	2500	3500	5000	750	1500	2500	3500	5000
5	Blades	Port of Houston, TX	South Dakota															
6		Gainesville, TX	South Dakota															
7		Port of Duluth, MN	South Dakota															
8		Grand Forks, ND	South Dakota															
9		Gainesville, TX	Port of Houston															
10		Port of Houston	Sioux City, IA										$96.56					
11		Sioux City, IA	South Dakota															
12		Europe	Port of Houston, TX/Port of Duluth, MN											$32.92	$57.00	$62.12	$146.49	$175.25
13																		
14	Hubs	Port of Houston, TX	South Dakota															
15		Port of Duluth, MN	South Dakota															
16		Chicago, IL	South Dakota															
17		Tehachapi, CA	South Dakota															
18		Europe	Port of Houston, TX/Port of Duluth, MN											2.588778	6.027214	4.781378	3.454545	3.355824
19																		
20	Nacelle	Port of Houston, TX	South Dakota			$7.01	$21.60											
21		Port of Duluth, MN	South Dakota			$6.07	$20.59											
22		Chicago, IL	South Dakota			$6.37	$20.92											
23		Tehachapi, CA	South Dakota			$7.24	$21.84											
24		Port of Houston	Sioux City, IA								$44.66	$58.97	$44.32					
25		Europe	Port of Houston, TX/Port of Duluth, MN											$15.63	$18.31	$16.02	$13.89	$15.26
26		Sioux City, IA	South Dakota															
27																		
28	Towers	Canutillo, TX (El Paso)	South Dakota															
29		Dallas, TX	South Dakota															
30		Shreveport, LA	South Dakota															
31		Europe	Port of Houston, TX/Port of Duluth, MN															
32		Canutillo, TX (El Paso)	Port of Houston															
33		Dallas, TX	Port of Houston															
34		Shreveport, LA	Port of Houston															
35		Port of Houston	Sioux City, IA															
36		Sioux City, IA	South Dakota															
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	A	B	C	D	E	F	G	H	I	J	K	L	M
1				TRUCK TRANSPORT COSTS					STEERABLE DOLLY TRANSPORT COSTS				
2				Detailed Costs in Appendix D					Detailed Costs in Appendix E				
3				Turbines					Turbines				
4	**Component**	**Origin**	**Destination**	750	1500	2500	3500	5000	750	1500	2500	3500	5000
5	Blades	Port of Houston, TX	South Dakota	$7.14	$6.76	$7.03	$11.56						
6		Gainesville, TX	South Dakota	$6.40	$6.06	$6.30	$10.37						
7		Port of Duluth, MN	South Dakota	$3.47	$3.29	$4.89	$7.42	$7.29					
8		Grand Forks, ND	South Dakota	$2.91	$2.76	$4.10	$5.51	$5.31					
9		Gainesville, TX	Port of Houston					$2.19					
10		Port of Houston	Sioux City, IA										
11		Sioux City, IA	South Dakota					$1.66					
12		Europe	Port of Houston, TX/Port of Duluth, MN										
13													
14	Hubs	Port of Houston, TX	South Dakota	$2.27	$2.23	$2.69	$2.43	$2.14					
15		Port of Duluth, MN	South Dakota	$1.74	$1.99	$1.44	$1.30	$1.15					
16		Chicago, IL	South Dakota	$2.19	$2.52	$1.82	$1.65	$1.45					
17		Tehachapi, CA	South Dakota	$2.98	$2.93	$3.53	$3.19	$2.81					
18		Europe	Port of Houston, TX/Port of Duluth, MN										
19													
20	Nacelle	Port of Houston, TX	South Dakota	$5.19	$5.59	$5.95	$4.05	$2.82					
21		Port of Duluth, MN	South Dakota	$3.82	$2.79	$3.36	$2.26	$1.57				$66.56	$49.23
22		Chicago, IL	South Dakota	$5.26	$4.03	$4.55	$2.85	$1.98				$68.84	$51.61
23		Tehachapi, CA	South Dakota	$6.81	$7.32	$8.24	$5.32	$3.69				$108.08	$82.44
24		Port of Houston	Sioux City, IA										
25		Europe	Port of Houston, TX/Port of Duluth, MN										
26		Sioux City, IA	South Dakota									$47.02	$33.91
27													
28	Towers	Canutillo, TX (El Paso)	South Dakota	$16.52	$27.68	$36.71	$49.77	$53.09					
29		Dallas, TX	South Dakota	$16.66	$27.90	$37.01	$50.17	$53.52					
30		Shreveport, LA	South Dakota	$15.89	$26.61	$35.29	$47.84	$51.04					
31		Europe	Port of Houston, TX/Port of Duluth, MN										
32		Canutillo, TX (El Paso)	Port of Houston										
33		Dallas, TX	Port of Houston										
34		Shreveport, LA	Port of Houston										
35		Port of Houston	Sioux City, IA										
36		Sioux City, IA	South Dakota										
37													
38							**Turbine Rating**	**750 kW**	**1500 kW**	**2500 kW**	**3500 kW**	**5000 kW**	
39							**Notes:**	**I**	**II**	**III**	**IV**	**V**	
40				**Summary**	**U.S. Source - Short Haul**			**$26.25**	**$35.91**	**$45.76**	**$78.28**	**$111.38**	
41					**U.S. Source - Long Haul**			**$32.71**	**$43.99**	**$54.78**	**$89.79**	**$242.44**	
42					**European Sourced**			**$76.68**	**$117.08**	**$129.34**	**$244.77**	**$306.20**	
43					NP - Not Practical/Possible								
44				**Notes:**									
45					U.S. Source - Short Haul costs = Blades (D8) + Hubs (D16) + Nacelle (D22) + Towers (D30)								
46				**I**	U.S. Source - Long Haul costs = Blades (D6) + Hubs (D17) + Nacelle (D23) + Towers (D28)								
47					European Sourced = Blades (D7+X12) + Hubs (D15+X18) + Nacelle (D21+X25) + Towers (D28)								
48													
49					U.S. Source - Short Haul costs = Blades (E8) + Hubs (E16) + Nacelle (E22) + Towers (E30)								
50				**II**	U.S. Source - Long Haul costs = Blades (E6) + Hubs (E17) + Nacelle (E23) + Towers (E28)								
51					European Sourced = Blades (E7+Y12) + Hubs (E15+Y18) + Nacelle (E21+Y25) + Towers (E28)								
52													
53					U.S. Source - Short Haul costs = Blades (F8) + Hubs (F16) + Nacelle (F22) + Towers (F30)								
54				**III**	U.S. Source - Long Haul costs = Blades (F6) + Hubs (F17) + Nacelle (F23) + Towers (F28)								
55					European Sourced = Blades (F7+Z12) + Hubs (F15+Z18) + Nacelle (F21+Z25) + Towers (F28)								
56													
57					U.S. Source - Short Haul costs = Blades (G8) + Hubs (G16) + Nacelle (G22+Q22) + Towers (G30)								
58				**IV**	U.S. Source - Long Haul costs = Blades (G6) + Hubs (G17) + Nacelle (G23+Q23) + Towers (G28)								
59					European Sourced = Blades (G7+AA12) + Hubs (G15+AA18) + Nacelle (G21+Q21+AA25) + Towers (G28)								
60													
61					U.S. Source - Short Haul costs = Blades (H8) + Hubs (H16) + Nacelle (H22+M22) + Towers (H30)								
62				**V**	U.S. Source - Long Haul costs = Blades (H9+H11+W10) + Hubs (H17) + Nacelle (H23+M23) + Towers (H28)								
63					European Sourced = Blades (H7+AB12) + Hubs (H15+AB18) + Nacelle (H21+M21+AB25) + Towers (H28)								
64													

	A	B	C	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1				**RAIL TRANSPORT COSTS**					**BARGE TRANSPORT COSTS**					**OCEAN SHIPPING TRANSPORT COSTS**				
2				Detailed Costs in Appendix F					Detailed Costs in Appendix G					Detailed Costs in Appendix H				
3				Turbines					Turbines					Turbines				
4	**Component**	**Origin**	**Destination**	750	1500	2500	3500	5000	750	1500	2500	3500	5000	750	1500	2500	3500	5000
5	Blades	Port of Houston, TX	South Dakota															
6		Gainesville, TX	South Dakota															
7		Port of Duluth, MN	South Dakota															
8		Grand Forks, ND	South Dakota															
9		Gainesville, TX	Port of Houston															
10		Port of Houston	Sioux City, IA										$96.56					
11		Sioux City, IA	South Dakota															
12		Europe	Port of Houston, TX/Port of Duluth, MN											$32.92	$57.00	$62.12	$146.49	$175.25
13																		
14	Hubs	Port of Houston, TX	South Dakota															
15		Port of Duluth, MN	South Dakota															
16		Chicago, IL	South Dakota															
17		Tehachapi, CA	South Dakota															
18		Europe	Port of Houston, TX/Port of Duluth, MN											$2.59	$6.03	$4.78	$3.45	$3.36
19																		
20	Nacelle	Port of Houston, TX	South Dakota			$6.53	$20.97											
21		Port of Duluth, MN	South Dakota			$5.80	$20.18											
22		Chicago, IL	South Dakota			$6.04	$20.43											
23		Tehachapi, CA	South Dakota			$6.58	$21.15											
24		Port of Houston	Sioux City, IA									$58.97	$44.32					
25		Europe	Port of Houston, TX/Port of Duluth, MN											$15.63	$18.31	$16.02	$13.89	$15.26
26		Sioux City, IA	South Dakota															
27																		
28	Towers	Canutillo, TX (El Paso)	South Dakota															
29		Dallas, TX	South Dakota															
30		Shreveport, LA	South Dakota															
31		Europe	Port of Houston, TX/Port of Duluth, MN											$482	$636	$819	$963	$1,156
32		Canutillo, TX (El Paso)	Port of Houston															
33		Dallas, TX	Port of Houston															
34		Shreveport, LA	Port of Houston															
35		Port of Houston	Sioux City, IA															
36		Sioux City, IA	South Dakota															
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Appendix D
Truck Transport

Number of turbines	50				
Number of blades per turbine	3				
Total number of blades required	150				

Turbine Class	**750**	**1500**	**2500**	**3500**	**5000**
Rotor Diameter (m)	50	66	85	100	120
Swept Area (sq m)	1963	3421	5675	7854	11310
Rated Power kW (44% of swept area)	864	1505	2497	3456	4976
From Port of Houston (European suppliers)					
Costs per loaded-mile	$5.50	$5.50	$4.74	$9.50	
Estimated mileage per load	1,121	1,234	1,234	1,402	
Costs per load	$6,166	$6,787	$5,849	$13,319	
Number of blades per load	3	2	1	1	
Number of loads required	50	75	150	150	
Total costs	$308,275	$509,025	$877,374	$1,997,850	
Cost per turbine	$6,166	$10,181	$17,547	$39,957	
Costs per kW	$7.14	$6.76	$7.03	$11.56	
Costs per swept area	$3.14	$2.98	$3.09	$5.09	
From Gainesville, TX (Molded Fibre Glass, Inc.)					
Costs per loaded-mile	$5.50	$5.50	$4.74	$9.50	$11.00
Estimated mileage per load	1005	1106	1106	1257	330
Costs per load	$5,528	$6,083	$5,242	$11,942	$3,630
Number of blades per load	3	2	1	1	1
Number of loads required	50	75	150	150	150
Total costs	$276,375	$456,225	$786,366	$1,791,225	$544,500
Cost per turbine	$5,528	$9,125	$15,727	$35,825	$10,890
Costs per kW	$6.40	$6.06	$6.30	$10.37	$2.19
Costs per swept area	$2.82	$2.67	$2.77	$4.56	$0.96
From Port of Duluth, MN (European suppliers)					
Costs per loaded-mile	$5.00	$5.00	$6.17	$9.50	$11.00
Estimated mileage per load	600	660	660	900	1,100
Costs per load	$3,000	$3,300	$4,072	$8,550	$12,100
Number of blades per load	3	2	1	1	1
Number of loads required	50	75	150	150	150
Total costs	$150,000	$247,500	$610,830	$1,282,500	$1,815,000
Cost per turbine	$3,000	$4,950	$12,217	$25,650	$36,300
Costs per kW	$3.47	$3.29	$4.89	$7.42	$7.29
Costs per swept area	$1.53	$1.45	$2.15	$3.27	$3.21
From Grand Forks, ND (L-M Glasfiber)					
Costs per loaded-mile	$5.00	$5.00	$6.17	$9.50	$11.00
Estimated mileage per load	502	553	553	668	800
Costs per load	$2,510	$2,765	$3,412	$6,346	$8,800
Number of blades per load	3	2	1	1	1
Number of loads required	50	75	150	150	150
Total costs	$125,500	$207,375	$511,802	$951,900	$1,320,000
Cost per turbine	$2,510	$4,148	$10,236	$19,038	$26,400
Costs per kW	$2.91	$2.76	$4.10	$5.51	$5.31
Costs per swept area	$1.28	$1.21	$1.80	$2.42	$2.33
From Sioux City, Iowa					
Costs per loaded-mile					$11.00
Estimated mileage per load					250
Costs per load					$2,750
Number of blades per load					1
Number of loads required					150
Total costs					$412,500
Cost per turbine					$8,250
Costs per kW					$1.66
Costs per swept area					$0.73

Number of Turbines	50
Number of Hubs per turbine	1
Total number of Hubs required	50

Turbine Class	**750**	**1500**	**2500**	**3500**	**5000**
Rotor Diameter (m)	50	66	85	100	120
Swept Area (sq m)	1963	3421	5675	7854	11310
Rated Power kW (44% of swept area)	864	1505	2497	3456	4976
From Port of Houston (European suppliers)					
Costs per loaded-mile	$1.75	$3.00	$6.00	$7.50	$9.50
Estimated mileage per load	1,121	1,121	1,121	1,121	1,121
Costs per load	$1,962	$3,363	$6,726	$8,408	$10,650
Number of hubs per load	1	1	1	1	1
Number of loads required	50	50	50	50	50
Total costs	$98,088	$168,150	$336,300	$420,375	$532,475
Cost per turbine	$1,962	$3,363	$6,726	$8,408	$10,650
Costs per kW	$2.27	$2.23	$2.69	$2.43	$2.14
Costs per swept area	$1.00	$0.98	$1.19	$1.07	$0.94
From Port of Duluth, MN (European suppliers)					
Costs per loaded-mile	$2.50	$5.00	$6.00	$7.50	$9.50
Estimated mileage per load	600	600	600	600	600
Costs per load	$1,500	$3,000	$3,600	$4,500	$5,700
Number of hubs per load	1	1	1	1	1
Number of loads required	50	50	50	50	50
Total costs	$75,000	$150,000	$180,000	$225,000	$285,000
Cost per turbine	$1,500	$3,000	$3,600	$4,500	$5,700
Costs per kW	$1.74	$1.99	$1.44	$1.30	$1.15
Costs per swept area	$0.76	$0.88	$0.63	$0.57	$0.50
From Chicago, IL					
Costs per loaded-mile	$2.50	$5.00	$6.00	$7.50	$9.50
Estimated mileage per load	758	758	758	758	758
Costs per load	$1,895	$3,790	$4,548	$5,685	$7,201
Number of hubs per load	1	1	1	1	1
Number of loads required	50	50	50	50	50
Total costs	$94,750	$189,500	$227,400	$284,250	$360,050
Cost per turbine	$1,895	$3,790	$4,548	$5,685	$7,201
Costs per kW	$2.19	$2.52	$1.82	$1.65	$1.45
Costs per swept area	$0.97	$1.11	$0.80	$0.72	$0.64
From Tehachapi, CA					
Costs per loaded-mile	$1.75	$3.00	$6.00	$7.50	$9.50
Estimated mileage per load	1470	1470	1470	1470	1470
Costs per load	$2,573	$4,410	$8,820	$11,025	$13,965
Number of hubs per load	1	1	1	1	1
Number of loads required	50	50	50	50	50
Total costs	$128,625	$220,500	$441,000	$551,250	$698,250
Cost per turbine	$2,573	$4,410	$8,820	$11,025	$13,965
Costs per kW	$2.98	$2.93	$3.53	$3.19	$2.81
Costs per swept area	$1.31	$1.29	$1.55	$1.40	$1.23

Number of nacelles	50				
Number of nacelles per turbine	1				
Total number of nacelles required	50				

Turbine Class	**750**	**1500**	**2500**	**3500**	**5000**
Rotor Diameter (m)	50	66	85	100	120
Swept Area (sq m)	1963	3421	5675	7854	11310
Rated Power kW (44% of swept area)	864	1505	2497	3456	4976

From Port of Houston (European suppliers)			
Costs per loaded-mile	$4.00	$7.50	$11.00
Estimated mileage per load	1,121	1,121	1,121
Costs per load	$4,484	$8,408	$12,331
Number of nacelles per load	1	1	1
Number of loads required	50	50	50
Total costs	$224,200	$420,375	$616,550
Cost per turbine	$4,484	$8,408	$12,331
Costs per kW	$5.19	$5.59	$4.94
Costs per swept area	$2.28	$2.46	$2.17

From Port of Duluth, MN (European suppliers)			
Costs per loaded-mile	$5.50	$7.00	$11.00
Estimated mileage per load	600	600	600
Costs per load	$3,300	$4,200	$6,600
Number of nacelles per load	1	1	1
Number of loads required	50	50	50
Total costs	$165,000	$210,000	$330,000
Cost per turbine	$3,300	$4,200	$6,600
Costs per kW	$3.82	$2.79	$2.64
Costs per swept area	$1.68	$1.23	$1.16

From Chicago, IL			
Costs per loaded-mile	$6.00	$8.00	$11.00
Estimated mileage per load	758	758	758
Costs per load	$4,548	$6,064	$8,338
Number of nacelles per load	1	1	1
Number of loads required	50	50	50
Total costs	$227,400	$303,200	$416,900
Cost per turbine	$4,548	$6,064	$8,338
Costs per kW	$5.26	$4.03	$3.34
Costs per swept area	$2.32	$1.77	$1.47

From Tehachapi, CA			
Costs per loaded-mile	$4.00	$7.50	$11.00
Estimated mileage per load	1470	1470	1470
Costs per load	$5,880	$11,025	$16,170
Number of nacelles per load	1	1	1
Number of loads required	50	50	50
Total costs	$294,000	$551,250	$808,500
Cost per turbine	$5,880	$11,025	$16,170
Costs per kW	$6.81	$7.32	$6.48
Costs per swept area	$2.99	$3.22	$2.85

Number of turbines	50
Number of nacelles per turbine	1
Total number of nacelles required	50

Turbine Class	**2500**				**3500**				**5000**			
Rotor Diameter (m)	85				100				120			
Swept Area (sq m)	5675				7854				11310			
Rated Power kW (44% of swept area)	2497				3456				4976			
	Generator	Gear box	Nacelle	Total	Generator	Gear box	Nacelle	Total	Generator	Gear box	Nacelle	Total
Mass (kg)	8567	16660	85839		11867	24607	127575		16817	38115	199170	
From Port of Houston (European suppliers)	8670	13000	65000									
Costs per loaded-mile	$1.50	$1.50	$11.00		$1.50	$11.00	Rail or Barge or Dolly		$1.50	$11.00	Rail or Barge or Dolly	
Estimated mileage per load	1,121	1,121	1,121		1,121	1,121			1,121	1,121		
Costs per load	$1,682	$1,682	$12,331		$1,682	$12,331			$1,682	$12,331		
Number of units per load	2	1	1		1	1			1	1		
Number of loads required	25	50	50		50	50			50	50		
Total costs	$42,038	$84,075	$616,550	$742,663	$84,075	$616,550		$700,625	$84,075	$616,550		$700,625
Cost per turbine	$841	$1,682	$12,331	$14,853	$1,682	$12,331		$14,013	$1,682	$12,331		$14,013
Costs per kW	$0.34	$0.67	$4.94	$5.95	$0.49	$3.57		$4.05	$0.34	$2.48		$2.82
Costs per swept area	$0.15	$0.30	$2.17	$2.62	$0.21	$1.57		$1.78	$0.15	$1.09		$1.24
From Port of Duluth, MN (European suppliers)												
Costs per loaded-mile	$2.00	$2.00	$11.00		$2.00	$11.00			$2.00	$11.00		
Estimated mileage per load	600	600	600		600	600			600	600		
Costs per load	$1,200	$1,200	$6,600		$1,200	$6,600			$1,200	$6,600		
Number of units per load	2	1	1		1	1			1	1		
Number of loads required	25	50	50		50	50			50	50		
Total costs	$30,000	$60,000	$330,000	$420,000	$60,000	$330,000		$390,000	$60,000	$330,000		$390,000
Cost per turbine	$600	$1,200	$6,600	$8,400	$1,200	$6,600		$7,800	$1,200	$6,600		$7,800
Costs per kW	$0.24	$0.48	$2.64	$3.36	$0.35	$1.91		$2.26	$0.24	$1.33		$1.57
Costs per swept area	$0.11	$0.21	$1.16	$1.48	$0.15	$0.84		$0.99	$0.11	$0.58		$0.69
From Chicago, IL												
Costs per loaded-mile	$2.00	$2.00	$11.00		$2.00	$11.00			$2.00	$11.00		
Estimated mileage per load	758	758	758		758	758			758	758		
Costs per load	$1,516	$1,516	$8,338		$1,516	$8,338			$1,516	$8,338		
Number of nacelles per load	1	1	1		1	1			1	1		
Number of loads required	50	50	50		50	50			50	50		
Total costs	$75,800	$75,800	$416,900	$568,500	$75,800	$416,900		$492,700	$75,800	$416,900		$492,700
Cost per turbine	$1,516	$1,516	$8,338	$11,370	$1,516	$8,338		$9,854	$1,516	$8,338		$9,854
Costs per kW	$0.61	$0.61	$3.34	$4.55	$0.44	$2.41		$2.85	$0.30	$1.68		$1.98
Costs per swept area	$0.27	$0.27	$1.47	$2.00	$0.19	$1.06		$1.25	$0.13	$0.74		$0.87
From Tehachapi, CA												
Costs per loaded-mile	$1.50	$1.50	$11.00		$1.50	$11.00			$1.50	$11.00		
Estimated mileage per load	1470	1470	1470		1470	1470			1470	1470		
Costs per load	$2,205	$2,205	$16,170		$2,205	$16,170			$2,205	$16,170		
Number of nacelles per load	1	1	1		1	1			1	1		
Number of loads required	50	50	50		50	50			50	50		
Total costs	$110,250	$110,250	$808,500	$1,029,000	$110,250	$808,500		$918,750	$110,250	$808,500		$918,750
Cost per turbine	$2,205	$2,205	$16,170	$20,580	$2,205	$16,170		$18,375	$2,205	$16,170		$18,375
Costs per kW	$0.88	$0.88	$6.48	$8.24	$0.64	$4.68		$5.32	$0.44	$3.25		$3.69
Costs per swept area	$0.39	$0.39	$2.85	$3.63	$0.28	$2.06		$2.34	$0.19	$1.43		$1.62

Number of nacelles	50
Number of nacelles per turbine	1
Total number of blades required	50

Turbine Class		**750**			**1500**				
Rotor Diameter (m)	50				66				
Swept Area (sq m)	1963				3421				
Rated Power kW (44% of swept area)	864				1505				
From Canutillo, TX (El Paso)	Section 1	Section 2	Section 3	Total	Section 1	Section 2	Section 3	Section 4	Total
Costs per loaded-mile	$10.00	$1.45	$1.40	$12.85	$11.00	$11.00	$9.50	$6.00	$37.50
Estimated mileage per load	1,111	1,111	1,111	1,111	1,111	1,111	1,111	1,111	1,111
Costs per load	$11,110	$1,611	$1,555	$14,276	$12,221	$12,221	$10,555	$6,666	$41,663
Number of Towers per load	1	1	1		1	1	1	1	
Number of loads required	50	50	50		50	50	50	50	
Total costs	$555,500	$80,548	$77,770	$713,818	$611,050	$611,050	$527,725	$333,300	$2,083,125
Cost per turbine	$11,110	$1,611	$1,555	$14,276	$12,221	$12,221	$10,555	$6,666	$41,663
Costs per kW	$12.86	$1.86	$1.80	$16.52	$8.12	$8.12	$7.01	$4.43	$27.68
Costs per swept area	$5.66	$0.82	$0.79	$7.27	$3.57	$3.57	$3.09	$1.95	$12.18
From Dallas, TX	Section 1	Section 2	Section 3	Total	Section 1	Section 2	Section 3	Section 4	Total
Costs per loaded-mile	$10.00	$1.45	$1.40	$12.85	$11.00	$11.00	$9.50	$6.00	$37.50
Estimated mileage per load	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120
Costs per load	$11,200	$1,624	$1,568	$14,392	$12,320	$12,320	$10,640	$6,720	$42,000
Number of Towers per load	1	1	1		1	1	1	1	
Number of loads required	50	50	50		50	50	50	50	
Total costs	$560,000	$81,200	$78,400	$719,600	$616,000	$616,000	$532,000	$336,000	$2,100,000
Cost per turbine	$11,200	$1,624	$1,568	$14,392	$12,320	$12,320	$10,640	$6,720	$42,000
Costs per kW	$12.96	$1.88	$1.81	$16.66	$8.18	$8.18	$7.07	$4.46	$27.90
Costs per swept area	$5.70	$0.83	$0.80	$7.33	$3.60	$3.60	$3.11	$1.96	$12.28
From Shreveport, LA	Section 1	Section 2	Section 3	Total	Section 1	Section 2	Section 3	Section 4	Total
Costs per loaded-mile	$10.00	$1.45	$1.40	$12.85	$11.00	$11.00	$9.50	$6.00	$37.50
Estimated mileage per load	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068
Costs per load	$10,680	$1,549	$1,495	$13,724	$11,748	$11,748	$10,146	$6,408	$40,050
Number of Towers per load	1	1	1		1	1	1	1	
Number of loads required	50	50	50		50	50	50	50	
Total costs	$534,000	$77,430	$74,760	$686,190	$587,400	$587,400	$507,300	$320,400	$2,002,500
Cost per turbine	$10,680	$1,549	$1,495	$13,724	$11,748	$11,748	$10,146	$6,408	$40,050
Costs per kW	$12.36	$1.79	$1.73	$15.89	$7.80	$7.80	$6.74	$4.26	$26.61
Costs per swept area	$5.44	$0.79	$0.76	$6.99	$3.43	$3.43	$2.97	$1.87	$11.71

Number of nacelles
Number of nacelles per turbine
Total number of blades required

Turbine Class	2500					
Rotor Diameter (m)	85					
Swept Area (sq m)	5675					
Rated Power kW (44% of swept area)	2497					

From Canutillo, TX (El Paso)	Section 1	Section 2	Section 3	Section 4	Section 5	Total
Costs per loaded-mile	$8.00	$6.00	$1.50	$11.00	$9.50	$36.00
Estimated mileage per load	1,111	1,111	1,111	1,111	1,111	1,111
Costs per load	$8,888	$6,666	$1,667	$12,221	$10,555	$39,996
Number of Towers per load	0.25	0.25	0.25	1	1	
Number of loads required	200	200	200	50	50	
Total costs	$1,777,600	$1,333,200	$333,300	$611,050	$527,725	$4,582,875
Cost per turbine	$35,552	$26,664	$6,666	$12,221	$10,555	$91,658
Costs per kW	$14.24	$10.68	$2.67	$4.89	$4.23	$36.71
Costs per swept area	$6.27	$4.70	$1.17	$2.15	$1.86	$16.15

From Dallas, TX	Section 1	Section 2	Section 3	Section 4	Section 5	Total
Costs per loaded-mile	$8.00	$6.00	$1.50	$11.00	$9.50	$36.00
Estimated mileage per load	1,120	1,120	1,120	1,120	1,120	1,120
Costs per load	$8,960	$6,720	$1,680	$12,320	$10,640	$40,320
Number of Towers per load	0.25	0.25	0.25	1	1	
Number of loads required	200	200	200	50	50	
Total costs	$1,792,000	$1,344,000	$336,000	$616,000	$532,000	$4,620,000
Cost per turbine	$35,840	$26,880	$6,720	$12,320	$10,640	$92,400
Costs per kW	$14.35	$10.77	$2.69	$4.93	$4.26	$37.01
Costs per swept area	$6.32	$4.74	$1.18	$2.17	$1.88	$16.28

From Shreveport, LA	Section 1	Section 2	Section 3	Section 4	Section 5	Total
Costs per loaded-mile	$8.00	$6.00	$1.50	$11.00	$9.50	$36.00
Estimated mileage per load	1,068	1,068	1,068	1,068	1,068	1,068
Costs per load	$8,544	$6,408	$1,602	$11,748	$10,146	$38,448
Number of Towers per load	0.25	0.25	0.25	1	1	
Number of loads required	200	200	200	50	50	
Total costs	$1,708,800	$1,281,600	$320,400	$587,400	$507,300	$4,405,500
Cost per turbine	$34,176	$25,632	$6,408	$11,748	$10,146	$88,110
Costs per kW	$13.69	$10.27	$2.57	$4.71	$4.06	$35.29
Costs per swept area	$6.02	$4.52	$1.13	$2.07	$1.79	$15.53

Number of nacelles
Number of nacelles per turbine
Total number of blades required

Turbine Class	3500						
Rotor Diameter (m)	100						
Swept Area (sq m)	7854						
Rated Power kW (44% of swept area)	3456						

From Canutillo, TX (El Paso)	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Total
Costs per loaded-mile	$11.00	$9.50	$8.00	$6.00	$1.45	$11.00	$46.95
Estimated mileage per load	1,111	1,111	1,111	1,111	1,111	1,111	1,111
Costs per load	$12,221	$10,555	$8,888	$6,666	$1,611	$12,221	$52,161
Number of Towers per load	0.25	0.25	0.25	0.25	0.25	1	
Number of loads required	200	200	200	200	200	50	
Total costs	$2,444,200	$2,110,900	$1,777,600	$1,333,200	$322,190	$611,050	$8,599,140
Cost per turbine	$48,884	$42,218	$35,552	$26,664	$6,444	$12,221	$171,983
Costs per kW	$14.15	$12.22	$10.29	$7.72	$1.86	$3.54	$49.77
Costs per swept area	$6.22	$5.38	$4.53	$3.39	$0.82	$1.56	$21.90

From Dallas, TX	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Total
Costs per loaded-mile	$11.00	$9.50	$8.00	$6.00	$1.45	$11.00	$46.95
Estimated mileage per load	1,120	1,120	1,120	1,120	1,120	1,120	1,120
Costs per load	$12,320	$10,640	$8,960	$6,720	$1,624	$12,320	$52,584
Number of Towers per load	0.25	0.25	0.25	0.25	0.25	1	
Number of loads required	200	200	200	200	200	50	
Total costs	$2,464,000	$2,128,000	$1,792,000	$1,344,000	$324,800	$616,000	$8,668,800
Cost per turbine	$49,280	$42,560	$35,840	$26,880	$6,496	$12,320	$173,376
Costs per kW	$14.26	$12.32	$10.37	$7.78	$1.88	$3.57	$50.17
Costs per swept area	$6.27	$5.42	$4.56	$3.42	$0.83	$1.57	$22.07

From Shreveport, LA	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Total
Costs per loaded-mile	$11.00	$9.50	$8.00	$6.00	$1.45	$11.00	$46.95
Estimated mileage per load	1,068	1,068	1,068	1,068	1,068	1,068	1,068
Costs per load	$11,748	$10,146	$8,544	$6,408	$1,549	$11,748	$50,143
Number of Towers per load	0.25	0.25	0.25	0.25	0.25	1	
Number of loads required	200	200	200	200	200	50	
Total costs	$2,349,600	$2,029,200	$1,708,800	$1,281,600	$309,720	$587,400	$8,266,320
Cost per turbine	$46,992	$40,584	$34,176	$25,632	$6,194	$11,748	$165,326
Costs per kW	$13.60	$11.74	$9.89	$7.42	$1.79	$3.40	$47.84
Costs per swept area	$5.98	$5.17	$4.35	$3.26	$0.79	$1.50	$21.05

Number of nacelles
Number of nacelles per turbine
Total number of blades required

Turbine Class				**5000**				
Rotor Diameter (m)	120							
Swept Area (sq m)	11,310							
Rated Power kW (44% of swept area)	4976							

From Canutillo, TX (El Paso)	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Total
Costs per loaded-mile	$11.00	$11.00	$11.00	$9.50	$9.50	$6.00	$1.45	$59.45
Estimated mileage per load	1,111	1,111	1,111	1,111	1,111	1,111	1,111	1,111
Costs per load	$12,221	$12,221	$12,221	$10,555	$10,555	$6,666	$1,611	$66,049
Number of Towers per load	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
Number of loads required	200	200	200	200	200	200	200	
Total costs	$2,444,200	$2,444,200	$2,444,200	$2,110,900	$2,110,900	$1,333,200	$322,190	$13,209,790
Cost per turbine	$48,884	$48,884	$48,884	$42,218	$42,218	$26,664	$6,444	$264,196
Costs per kW	$9.82	$9.82	$9.82	$8.48	$8.48	$5.36	$1.29	$53.09
Costs per swept area	$4.32	$4.32	$4.32	$3.73	$3.73	$2.36	$0.57	$23.36

From Dallas, TX	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Total
Costs per loaded-mile	$11.00	$11.00	$11.00	$9.50	$9.50	$6.00	$1.45	$59.45
Estimated mileage per load	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120
Costs per load	$12,320	$12,320	$12,320	$10,640	$10,640	$6,720	$1,624	$66,584
Number of Towers per load	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
Number of loads required	200	200	200	200	200	200	200	
Total costs	$2,464,000	$2,464,000	$2,464,000	$2,128,000	$2,128,000	$1,344,000	$324,800	$13,316,800
Cost per turbine	$49,280	$49,280	$49,280	$42,560	$42,560	$26,880	$6,496	$266,336
Costs per kW	$9.90	$9.90	$9.90	$8.55	$8.55	$5.40	$1.31	$53.52
Costs per swept area	$4.36	$4.36	$4.36	$3.76	$3.76	$2.38	$0.57	$23.55

From Shreveport, LA	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Total
Costs per loaded-mile	$11.00	$11.00	$11.00	$9.50	$9.50	$6.00	$1.45	$59.45
Estimated mileage per load	1,068	1,068	1,068	1,068	1,068	1,068	1,068	1,068
Costs per load	$11,748	$11,748	$11,748	$10,146	$10,146	$6,408	$1,549	$63,493
Number of Towers per load	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
Number of loads required	200	200	200	200	200	200	200	
Total costs	$2,349,600	$2,349,600	$2,349,600	$2,029,200	$2,029,200	$1,281,600	$309,720	$12,698,520
Cost per turbine	$46,992	$46,992	$46,992	$40,584	$40,584	$25,632	$6,194	$253,970
Costs per kW	$9.44	$9.44	$9.44	$8.16	$8.16	$5.15	$1.24	$51.04
Costs per swept area	$4.16	$4.16	$4.16	$3.59	$3.59	$2.27	$0.55	$22.46

Appendix E
Dolly Transport

Number of turbines	50
Number of blades per turbine	3
Total number of blades required	150

Turbine Class	**750**	**1500**	**2500**	**3500**	**5000**
Rotor Diameter (m)	50	66	85	100	120
Swept Area (sq m)	1963	3421	5675	7854	11310
Rated Power kW (44% of swept area)	864	1505	2497	3456	4976

From Port of Houston (European suppliers)	
Costs per loaded-mile	$0.00
Estimated mileage per load	1,402
Costs per load	$0
Number of blades per load	1
Number of loads required	150
Total costs	$0
Cost per turbine	$0
Costs per kW	$0.00
Costs per swept area	$0.00

From Gainesville, TX (Molded Fibre Glass, Inc.) To Port of Houston	
Costs per loaded-mile	$0.00
Estimated mileage per load	1257
Costs per load	$0
Number of blades per load	1
Number of loads required	150
Total costs	$0
Cost per turbine	$0
Costs per kW	$0.00
Costs per swept area	$0.00

From Port of Duluth, MN (European suppliers)	
Costs per loaded-mile	$11.00
Estimated mileage per load	1,100
Costs per load	$12,100
Number of blades per load	1
Number of loads required	150
Total costs	$1,815,000
Cost per turbine	$36,300
Costs per kW	$7.29
Costs per swept area	$3.21

From Grand Forks, ND (L-M Glasfiber)	
Costs per loaded-mile	$11.00
Estimated mileage per load	800
Costs per load	$8,800
Number of blades per load	1
Number of loads required	150
Total costs	$1,320,000
Cost per turbine	$26,400
Costs per kW	$5.31
Costs per swept area	$2.33

Number of nacelles	50			
Number of nacelles per turbine	1			
Total number of nacelles required	50			

Turbine Class	**2500**	**3500**	**5000**
Rotor Diameter (m)	85	100	120
Swept Area (sq m)	5675	7854	11310
Rated Power kW (44% of swept area)	2497	3456	4976
From Sioux City, Iowa (European suppliers)			
Costs per loaded-mile	$50.00	$75.00	$100.00
Estimated mileage per load	250	250	250
Costs per load	$12,500	$18,750	$25,000
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000
Number of nacelles per load	1	1	1
Number of loads required	50	50	50
Total costs	$8,125,000	$8,437,500	$8,750,000
Cost per turbine	$162,500	$168,750	$175,000
Costs per kW	$65.08	$48.83	$35.17
Costs per swept area	$28.64	$21.49	$15.47
From Port of Duluth, MN (European suppliers)			
Costs per loaded-mile	$50.00	$75.00	$100.00
Estimated mileage per load	600	600	600
Costs per load	$30,000	$45,000	$60,000
Utility, DOT, Police Assistance	$200,000	$200,000	$200,000
Number of nacelles per load	1	1	1
Number of loads required	50	50	50
Total costs	$11,500,000	$12,250,000	$13,000,000
Cost per turbine	$230,000	$245,000	$260,000
Costs per kW	$92.12	$70.90	$52.25
Costs per swept area	$40.53	$31.19	$22.99
From Chicago, IL			
Costs per loaded-mile	$50.00	$75.00	$100.00
Estimated mileage per load	758	758	758
Costs per load	$37,900	$56,850	$75,800
Utility, DOT, Police Assistance	$200,000	$200,000	$200,000
Number of nacelles per load	1	1	1
Number of loads required	50	50	50
Total costs	$11,895,000	$12,842,500	$13,790,000
Cost per turbine	$237,900	$256,850	$275,800
Costs per kW	$95.28	$74.33	$55.42
Costs per swept area	$41.92	$32.70	$24.39
From Tehachapi, CA			
Costs per loaded-mile	$50.00	$75.00	$100.00
Estimated mileage per load	1470	1470	1470
Costs per load	$73,500	$110,250	$147,000
Utility, DOT, Police Assistance	$300,000	$300,000	$300,000
Number of nacelles per load	1	1	1
Number of loads required	50	50	50
Total costs	$18,675,000	$20,512,500	$22,350,000
Cost per turbine	$373,500	$410,250	$447,000
Costs per kW	$149.59	$118.72	$89.83
Costs per swept area	$65.82	$52.23	$39.52

Number of nacelles	50
number of nacelles per turbine	1
Total number of nacelles required	50

Turbine Class	3500	5000
Rotor Diameter (m)	100	120
Swept Area (sq m)	7854	11310
Rated Power kW (44% of swept area)	3456	4976
"Empty" Nacelle Mass	127575	199170
From Souix City, Iowa (European suppliers)		
Costs per loaded-mile	$50.00	$75.00
Estimated mileage per load	250	250
Costs per load	$12,500	$18,750
Utility, DOT, Police Assistance	$150,000	$150,000
Number of nacelles per load	1	1
Number of loads required	50	50
Total costs	$8,125,000	$8,437,500
Cost per turbine	$162,500	$168,750
Costs per kW	$47.02	$33.91
Costs per swept area	$20.69	$14.92
From Port of Duluth, MN (Eurpoean suppliers)		
Costs per loaded-mile	$50.00	$75.00
Estimated mileage per load	600	600
Costs per load	$30,000	$45,000
Utility, DOT, Police Assistance	$200,000	$200,000
Number of nacelles per load	1	1
Number of loads required	50	50
Total costs	$11,500,000	$12,250,000
Cost per turbine	$230,000	$245,000
Costs per kW	$66.56	$49.23
Costs per swept area	$29.28	$21.66
From Chicago, IL		
Costs per loaded-mile	$50.00	$75.00
Estimated mileage per load	758	758
Costs per load	$37,900	$56,850
Utility, DOT, Police Assistance	$200,000	$200,000
Number of nacelles per load	1	1
Number of loads required	50	50
Total costs	$11,895,000	$12,842,500
Cost per turbine	$237,900	$256,850
Costs per kW	$68.84	$51.61
Costs per swept area	$30.29	$22.71
From Tehachapi, CA		
Costs per loaded-mile	$50.00	$75.00
Estimated mileage per load	1470	1470
Costs per load	$73,500	$110,250
Utility, DOT, Police Assistance	$300,000	$300,000
Number of nacelles per load	1	1
Number of loads required	50	50
Total costs	$18,675,000	$20,512,500
Cost per turbine	$373,500	$410,250
Costs per kW	$108.08	$82.44
Costs per swept area	$47.56	$36.27

Number of turbines 50

Turbine Class	1500		2500	
Rotor Diameter (m)	66	85		
Swept Area (sq m)	3421	5675		
Rated Power kW (44% of swept area)	1505	2497		
From Canutillo, TX (El Paso) to Port of Houston	Section 1	Section 1	Section 2	Section 3
Costs per loaded-mile	$50.00	$50.00	$50.00	$50.00
Estimated mileage per load	780	780	780	780
Costs per load	$39,000	$39,000	$39,000	$39,000
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000	$150,000
Number of Towers per load	1	1	1	1
Number of loads required	50	50	50	50
Total costs	$9,450,000	$9,450,000	$9,450,000	$9,450,000
Cost per turbine	$189,000	$189,000	$189,000	$189,000
Costs per kW	$125.55	$75.70	$75.70	$75.70
Costs per swept area	$55.24	$33.31	$33.31	$33.31
From Dallas, TX to Port of Houston	Section 1	Section 1	Section 2	Section 3
Costs per loaded-mile	$50.00	$50.00	$50.00	$50.00
Estimated mileage per load	250	250	250	250
Costs per load	$12,500	$12,500	$12,500	$12,500
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000	$150,000
Number of Towers per load	1	1	1	1
Number of loads required	50	50	50	50
Total costs	$8,125,000	$8,125,000	$8,125,000	$8,125,000
Cost per turbine	$162,500	$162,500	$162,500	$162,500
Costs per kW	$107.95	$65.08	$65.08	$65.08
Costs per swept area	$47.50	$28.64	$28.64	$28.64
From Shreveport, LA	Section 1	Section 1	Section 2	Section 3
Costs per loaded-mile	$50.00	$50.00	$50.00	$50.00
Estimated mileage per load	240	240	240	240
Costs per load	$12,000	$12,000	$12,000	$12,000
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000	$150,000
Number of Towers per load	1	1	1	1
Number of loads required	50	50	50	50
Total costs	$8,100,000	$8,100,000	$8,100,000	$8,100,000
Cost per turbine	$162,000	$162,000	$162,000	$162,000
Costs per kW	$107.62	$64.88	$64.88	$64.88
Costs per swept area	$47.35	$28.55	$28.55	$28.55
From Sioux City, IA to South Dakota	Section 1	Section 1	Section 2	Section 3
Costs per loaded-mile	$50.00	$50.00	$50.00	$50.00
Estimated mileage per load	250	250	250	250
Costs per load	$12,500	$12,500	$12,500	$12,500
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000	$150,000
Number of Towers per load	1	1	1	1
Number of loads required	50	50	50	50
Total costs	$8,125,000	$8,125,000	$8,125,000	$8,125,000
Cost per turbine	$162,500	$162,500	$162,500	$162,500
Costs per kW	$107.95	$65.08	$65.08	$65.08
Costs per swept area	$47.50	$28.64	$28.64	$28.64

Number of turbines

Turbine Class			3500						5000			
Rotor Diameter (m)	100					120						
Swept Area (sq m)	7854					11310						
Rated Power kW (44% of swept area)	3456					4976						
From Canutillo, TX (El Paso) to Port of Houston	Section 1	Section 2	Section 3	Section 4	Section 5	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
Costs per loaded-mile	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00
Estimated mileage per load	780	780	780	780	780	780	780	780	780	780	780	780
Costs per load	$39,000	$39,000	$39,000	$39,000	$39,000	$39,000	$39,000	$39,000	$39,000	$39,000	$39,000	$39,000
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Number of Towers per load	1	1	1	1	1	1	1	1	1	1	1	1
Number of loads required	50	50	50	50	50	50	50	50	50	50	50	50
Total costs	$9,450,000	$9,450,000	$9,450,000	$9,450,000	$9,450,000	$9,450,000	$9,450,000	$9,450,000	$9,450,000	$9,450,000	$9,450,000	$9,450,000
Cost per turbine	$189,000	$189,000	$189,000	$189,000	$189,000	$189,000	$189,000	$189,000	$189,000	$189,000	$189,000	$189,000
Costs per kW	$54.69	$54.69	$54.69	$54.69	$54.69	$37.98	$37.98	$37.98	$37.98	$37.98	$37.98	$37.98
Costs per swept area	$24.06	$24.06	$24.06	$24.06	$24.06	$16.71	$16.71	$16.71	$16.71	$16.71	$16.71	$16.71
From Dallas, TX to Port of Houston	Section 1	Section 2	Section 3	Section 4	Section 5	Section 1	Section 2	Section 3	Section 4	8729	20941	Section 7
Costs per loaded-mile	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00
Estimated mileage per load	250	250	250	250	250	250	250	250	250	250	250	250
Costs per load	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Number of Towers per load	1	1	1	1	1	1	1	1	1	1	1	1
Number of loads required	50	50	50	50	50	50	50	50	50	50	50	50
Total costs	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000
Cost per turbine	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500
Costs per kW	$47.02	$47.02	$47.02	$47.02	$47.02	$32.65	$32.65	$32.65	$32.65	$32.65	$32.65	$32.65
Costs per swept area	$20.69	$20.69	$20.69	$20.69	$20.69	$14.37	$14.37	$14.37	$14.37	$14.37	$14.37	$14.37
From Shreveport, LA	Section 1	Section 2	Section 3	Section 4	Section 5	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
Costs per loaded-mile	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00
Estimated mileage per load	240	240	240	240	240	240	240	240	240	240	240	240
Costs per load	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000	$12,000
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Number of Towers per load	1	1	1	1	1	1	1	1	1	1	1	1
Number of loads required	50	50	50	50	50	50	50	50	50	50	50	50
Total costs	$8,100,000	$8,100,000	$8,100,000	$8,100,000	$8,100,000	$8,100,000	$8,100,000	$8,100,000	$8,100,000	$8,100,000	$8,100,000	$8,100,000
Cost per turbine	$162,000	$162,000	$162,000	$162,000	$162,000	$162,000	$162,000	$162,000	$162,000	$162,000	$162,000	$162,000
Costs per kW	$46.88	$46.88	$46.88	$46.88	$46.88	$32.55	$32.55	$32.55	$32.55	$32.55	$32.55	$32.55
Costs per swept area	$20.63	$20.63	$20.63	$20.63	$20.63	$14.32	$14.32	$14.32	$14.32	$14.32	$14.32	$14.32
From Sioux City, IA to South Dakota	Section 1	Section 2	Section 3	Section 4	Section 5	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
Costs per loaded-mile	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00	$50.00
Estimated mileage per load	250	250	250	250	250	250	250	250	250	250	250	250
Costs per load	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500	$12,500
Utility, DOT, Police Assistance	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Number of Towers per load	1	1	1	1	1	1	1	1	1	1	1	1
Number of loads required	50	50	50	50	50	50	50	50	50	50	50	50
Total costs	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000	$8,125,000
Cost per turbine	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500	$162,500
Costs per kW	$47.02	$47.02	$47.02	$47.02	$47.02	$32.65	$32.65	$32.65	$32.65	$32.65	$32.65	$32.65
Costs per swept area	$20.69	$20.69	$20.69	$20.69	$20.69	$14.37	$14.37	$14.37	$14.37	$14.37	$14.37	$14.37

Appendix F
Rail Transport

Number of nacelles	50
Number of nacelles per turbine	1
Total number of nacelles required	50

Turbine Class	**750**	**1500**	**2500**	**3500**	**5000**
Rotor Diameter (m)	50	66	85	100	120
Swept Area (sq m)	1963	3421	5675	7854	11310
Rated Power kW (44% of swept area)	864	1505	2497	3456	4976
Nacelle Mass (kg)	31,081	60,517	111,065	164,049	254,102
					Too Heavy for Rail
From Port of Duluth, MN (European suppliers)					
Costs per kg	$0.057	$0.042	$0.039	$0.039	
Costs per Turbine	$1,765	$2,560	$4,308	$6,363	
Rail Car Rental	$3,000	$3,000	$3,000	$3,000	
Rail car use fee	$2,000	$2,000	$2,000	$2,000	
50 mile Dolly Costs	$550	$550	$550	$52,500	
Total Rail Costs	$365,770	$405,493	$492,911	$3,193,173	
Crane Rental - Offloading	$215,000	$215,000	$215,000	$315,000	
Misc Labor	$50,000	$50,000	$50,000	$50,000	
Subtotal	$630,770	$670,493	$757,911	$3,558,173	
Grand total per turbine	$12,615	$13,410	$15,158	$71,163	
Costs per kW	$14.60	$8.91	$6.07	$20.59	
Costs per swept area	$6.42	$3.92	$2.67	$9.06	
From Chicago, IL					
Costs per kg	$0.064	$0.049	$0.046	$0.046	
Costs per Turbine	$1,980	$2,977	$5,065	$7,481	
Rail Car Rental	$3,000	$3,000	$3,000	$3,000	
Rail car use fee	$2,000	$2,000	$2,000	$2,000	
50 mile Dolly Costs	$550	$550	$550	$52,500	
Total Rail Costs	$376,493	$426,372	$530,728	$3,249,032	
Crane Rental - Offloading	$215,000	$215,000	$215,000	$315,000	
Misc Labor	$50,000	$50,000	$50,000	$50,000	
Subtotal	$641,493	$691,372	$795,728	$3,614,032	
Grand total per turbine	$12,830	$13,827	$15,915	$72,281	
Costs per kW	$14.85	$9.19	$6.37	$20.92	
Costs per swept area	$6.53	$4.04	$2.80	$9.20	
From Port of Houston, TX					
Costs per kg	$0.079	$0.064	$0.060	$0.060	
Costs per Turbine	$2,452	$3,843	$6,664	$9,843	
Rail Car Rental	$3,000	$3,000	$3,000	$3,000	
Rail car use fee	$2,000	$2,000	$2,000	$2,000	
50 mile Dolly Costs	$550	$550	$550	$52,500	
Total Rail Costs	$400,115	$469,641	$610,695	$3,367,147	
Crane Rental - Offloading	$215,000	$215,000	$215,000	$315,000	
Misc Labor	$50,000	$50,000	$50,000	$50,000	
Subtotal	$665,115	$734,641	$875,695	$3,732,147	
Grand total per turbine	$13,302	$14,693	$17,514	$74,643	
Costs per kW	$15.40	$9.76	$7.01	$21.60	
Costs per swept area	$6.77	$4.29	$3.09	$9.50	
From Tehachapi, CA					
Costs per kg	$0.080	$0.075	$0.065	$0.065	
Costs per Turbine	$2,486	$4,539	$7,219	$10,663	
Rail Car Rental	$3,000	$3,000	$3,000	$3,000	
Rail car use fee	$2,000	$2,000	$2,000	$2,000	
50 mile Dolly Costs	$550	$550	$550	$52,500	
Total Rail Costs	$401,824	$504,439	$638,461	$3,408,159	
Crane Rental - Offloading	$215,000	$215,000	$215,000	$315,000	
Misc Labor	$50,000	$50,000	$50,000	$50,000	
Subtotal	$666,824	$769,439	$903,461	$3,773,159	
Grand total per turbine	$13,336	$15,389	$18,069	$75,463	
Costs per kW	$15.44	$10.22	$7.24	$21.84	
Costs per swept area	$6.79	$4.50	$3.18	$9.61	

Number of nacelles	50
Number of nacelles per turbine	1
Total number of nacelles required	50

Turbine Class	750	1500	2500	3500	5000
Rotor Diameter (m)	50	66	85	100	120
Swept Area (sq m)	1963	3421	5675	7854	11310
Rated Power kW (44% of swept area)	864	1505	2497	3456	4976
"Empty" Nacelle Mass (kg)	23,311	46,173	85,839	127,575	199,170
					Too Heavy for Rail
From Port of Duluth, MN (European suppliers)					
Costs per kg	$0.057	$0.048	$0.042	$0.039	
Costs per Turbine	$1,324	$2,216	$3,631	$4,949	
Rail Car Rental	$3,000	$3,000	$3,000	$3,000	
Rail car use fee	$2,000	$2,000	$2,000	$2,000	
50 mile Dolly Costs	$550	$550	$550	$52,500	
Total Rail Costs	$343,703	$388,315	$459,049	$3,122,432	
Crane Rental - Offloading	$215,000	$215,000	$215,000	$315,000	
Misc Labor	$50,000	$50,000	$50,000	$50,000	
Subtotal	$608,703	$653,315	$724,049	$3,487,432	
Grand total per turbine	$12,174	$13,066	$14,481	$69,749	
Costs per kW	$14.09	$8.68	$5.80	$20.18	
Costs per swept area	$6.20	$3.82	$2.55	$8.88	
From Chicago, IL					
Costs per kg	$0.064	$0.055	$0.049	$0.046	
Costs per Turbine	$1,485	$2,540	$4,223	$5,817	
Rail Car Rental	$3,000	$3,000	$3,000	$3,000	
Rail car use fee	$2,000	$2,000	$2,000	$2,000	
50 mile Dolly Costs	$550	$550	$550	$52,500	
Total Rail Costs	$351,746	$404,476	$488,664	$3,165,871	
Crane Rental - Offloading	$215,000	$215,000	$215,000	$315,000	
Misc Labor	$50,000	$50,000	$50,000	$50,000	
Subtotal	$616,746	$669,476	$753,664	$3,530,871	
Grand total per turbine	$12,335	$13,390	$15,073	$70,617	
Costs per kW	$14.28	$8.89	$6.04	$20.43	
Costs per swept area	$6.28	$3.91	$2.66	$8.99	
From Port of Houston, TX					
Costs per kg	$0.079	$0.069	$0.064	$0.060	
Costs per Turbine	$1,839	$3,204	$5,451	$7,655	
Rail Car Rental	$3,000	$3,000	$3,000	$3,000	
Rail car use fee	$2,000	$2,000	$2,000	$2,000	
50 mile Dolly Costs	$550	$550	$550	$52,500	
Total Rail Costs	$369,462	$437,720	$550,039	$3,257,725	
Crane Rental - Offloading	$215,000	$215,000	$215,000	$315,000	
Misc Labor	$50,000	$50,000	$50,000	$50,000	
Subtotal	$634,462	$702,720	$815,039	$3,622,725	
Grand total per turbine	$12,689	$14,054	$16,301	$72,455	
Costs per kW	$14.69	$9.34	$6.53	$20.97	
Costs per swept area	$6.46	$4.11	$2.87	$9.23	
From Tehachapi, CA					
Costs per kg	$0.080	$0.075	$0.065	$0.065	
Costs per Turbine	$1,865	$3,463	$5,580	$8,292	
Rail Car Rental	$3,000	$3,000	$3,000	$3,000	
Rail car use fee	$2,000	$2,000	$2,000	$2,000	
50 mile Dolly Costs	$550	$550	$550	$52,500	
Total Rail Costs	$370,744	$450,649	$556,477	$3,289,619	
Crane Rental - Offloading	$215,000	$215,000	$215,000	$315,000	
Misc Labor	$50,000	$50,000	$50,000	$50,000	
Subtotal	$635,744	$715,649	$821,477	$3,654,619	
Grand total per turbine	$12,715	$14,313	$16,430	$73,092	
Costs per kW	$14.72	$9.51	$6.58	$21.15	
Costs per swept area	$6.48	$4.18	$2.90	$9.31	

Appendix G
Barge Transport

Barge Analysis from Houston, TX to Sioux City, IA

Number of Turbines					
	750	1500	2500	3500	5000
Rotor Diameter (m)		66	85	100	120
Calculated Power (kW)		1505	2497	3456	4976
Blades					
Barge costs per Load					$175,000
Number of Truck/Blade Loads per Barge					2
Volume of Blade Load (cu. m)					1454
Load/Lash/Release Lash Costs per cubic m					$50
Total Load/Lash/Release per Barge					$145,350
Total Barge Costs per load					$320,350
Number of Turbines					50
Number of Blades per Turbine					3
Total Number of Blades					150
Number of Barge Loads Required					75
Total Barge Costs					$24,026,250
Barge Costs per Turbine					$480,525
Barge Costs per kW					$96.56

	750	1500	2500	3500	5000
Rotor Diameter (m)		66	85	100	120
Calculated Power (kW)		1505	2497	3456	4976
Nacelles					
Barge costs per Load			$175,000	$175,000	$175,000
Number of Dolly/Nacelle Loads per Barge			2	1	1
Volume of Dolly/Nacelle Load (cu. m)			480	576	911
Load/Lash/Release Lash Costs per cubic m			$50	$50	$50
Total Load/Lash/Release per Barge			$48,000	$28,800	$45,563
Total Barge Costs per load			$223,000	$203,800	$220,563
Number of Turbines			50	50	50
Number of nacelles per Turbine			1	1	1
Total Number of nacelles			50	50	50
Number of Barge Loads Required			25	50	50
Total Barge Costs			$5,575,000	$10,190,000	$11,028,125
Barge Costs per Turbine			$111,500	$203,800	$220,563
Barge Costs per kW			$44.66	$58.97	$44.32

	750	1500	2500	3500	5000
Rotor Diameter (m)		66	85	100	120
Calculated Power (kW)		1505	2497	3456	4976
"Empty" Nacelle Mass				127,575	199,170
Nacelles					
Barge costs per Load				$175,000	$175,000
Number of Dolly/Nacelle Loads per Barge				1	1
Volume of Dolly/Nacelle Load (cu. m)				576	911
Load/Lash/Release Lash Costs per cubic m				$50	$50
Total Load/Lash/Release per Barge				$28,800	$45,563
Total Barge Costs per load				$203,800	$220,563
Number of Turbines				50	50
Number of nacelles per Turbine				1	1
Total Number of nacelles				50	50
Number of Barge Loads Required				50	50
Total Barge Costs				$10,190,000	$11,028,125
Barge Costs per Turbine				$203,800	$220,563
Barge Costs per kW				$58.97	$44.32

Turbine Class	1500	2500		
Rotor Diameter (m)	66	85		
Swept Area (sq m)	3421	5675		
Rated Power kW (44% of swept area)	1505	2497		
From Houston to Sioux City, Iowa	Section 1	Section 1	Section 2	Section 3
Barge costs per Load	$175,000	$175,000	$175,000	$175,000
Number of Dolly/Tower Section Loads per Barge	4	2	3	3
Volume of Load (cu. m)	447	794	633	490
Load/Lash/Release Lash Costs per cubic m	$50	$50	$50	$50
Total Load/Lash/Release per Barge	$89,327	$79,415	$94,901	$73,430
Total Barge Costs per load	$264,327	$254,415	$269,901	$248,430
Number of Turbines	50	50	50	50
Number of Sections per Turbine	1	1	1	1
Total Number of Sections	50	50	50	50
Number of Barge Loads Required	12.5	25.0	16.7	16.7
Total Barge Costs	$3,304,091	$6,360,377	$4,498,351	$4,140,492
Barge Costs per Turbine	$66,082	$127,208	$89,967	$82,810
Barge Costs per kW	$43.90	$50.95	$36.03	$33.17
Total Costs per kW	$43.90	$120.15		

Turbine Class	**3500**				
Rotor Diameter (m)	100				
Swept Area (sq m)	7854				
Rated Power kW (44% of swept area)	3456				
From Houston to Sioux City, Iowa	Section 1	Section 2	Section 3	Section 4	Section 5
Barge costs per Load	$175,000	$175,000	$175,000	$175,000	$175,000
Number of Dolly/Tower Section Loads per Barge	1	2	2	3	3
Volume of Load (cu. m)	1104	914	742	598	471
Load/Lash/Release Lash Costs per cubic m	$50	$50	$50	$50	$50
Total Load/Lash/Release per Barge	$55,220	$91,399	$74,159	$89,764	$70,591
Total Barge Costs per load	$230,220	$266,399	$249,159	$264,764	$245,591
Number of Turbines	50	50	50	50	50
Number of Sections per Turbine	1	1	1	1	1
Total Number of Sections	50	50	50	50	50
Number of Barge Loads Required	50.0	25.0	25.0	16.7	16.7
Total Barge Costs	$11,510,989	$6,659,979	$6,228,974	$4,412,735	$4,093,176
Barge Costs per Turbine	$230,220	$133,200	$124,579	$88,255	$81,864
Barge Costs per kW	$66.62	$38.54	$36.05	$25.54	$23.69
Total Costs per kW	$190.44				

Turbine Class	**5000**
Rotor Diameter (m)	120
Swept Area (sq m)	11,310
Rated Power kW (44% of swept area)	4976

From Houston to Sioux City, Iowa	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
Barge costs per Load	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000
Number of Dolly/Tower Section Loads per Barge	1	1	1	2	2	3	3
Volume of Load (cu. m)	1638	1401	1183	983	815	650	504
Load/Lash/Release Lash Costs per cubic m	$50	$50	$50	$50	$50	$50	$50
Total Load/Lash/Release per Barge	$81,904	$70,058	$59,136	$98,278	$81,464	$97,541	$75,662
Total Barge Costs per load	$256,904	$245,058	$234,136	$273,278	$256,464	$272,541	$250,662
Number of Turbines	50	50	50	50	50	50	50
Number of Sections per Turbine	1	1	1	1	1	1	1
Total Number of Sections	50	50	50	50	50	50	50
Number of Barge Loads Required	50.0	50.0	50.0	25.0	25.0	16.7	16.7
Total Barge Costs	$12,845,218	$12,252,876	$11,706,783	$6,831,939	$6,411,594	$4,542,357	$4,177,702
Barge Costs per Turbine	$256,904	$245,058	$234,136	$136,639	$128,232	$90,847	$83,554
Barge Costs per kW	$51.63	$49.25	$47.05	$27.46	$25.77	$18.26	$16.79

Total Costs per kW	$236.19

Appendix H
Ocean Transport

Name	750	1500	2500	3500	5000
Rotor Diameter	50	66	85	100	120
Area	1963	3421	5675	7854	11310
Rating	864	1505	2497	3456	4976
			Costs Per kW		
Blades	$32.92	$57.00	$62.12	$146.49	$175.25
Hub	$2.59	$6.03	$4.78	$3.45	$3.36
Nacelle	$15.63	$18.31	$16.02	$13.89	$15.26
Tower	$482	$636	$819	$963	$1,156
Total	$533.56	$717.67	$902.03	$1,127.23	$1,349.64

Number of Turbines		50
Number of Blades per Turbine		3

Ocean Cargo Cost:

To Duluth, MN	$250	per metric ton or cubic meter, whichever is greater
To Houston , TX	$250	per metric ton or cubic meter, whichever is greater

		750	1500	2500	3500	5000
Rotor Diameter	m	50	66	85	100	120
Swept Area	sq. m	1963	3421	5675	7854	11310
Rated Power	kW	864	1505	2497	3456	4976
Blades						
Length	m	25	33	42.5	50	60
Maximum Cord (height)	m	3.5	4	4.25	5	6
Maximum Diameter (width)	m	2.6	2.6	2.29	2.7	3.23
Mass	kg	2940	6101	11,868	18,197	29,393
Transport Mass	metric tons	2.9	6.1	11.9	18.2	29.4
Transport Volume	cu. M	228	343	414	675	1163
Cost per Transport Unit	$	$56,875	$85,800	$103,408	$168,750	$290,700
Blades per Transport Unit	each	6	3	2	1	1
Number of Transport Units		25	50	75	150	150
Total Transport Costs		$1,421,875	$4,290,000	$7,755,586	$25,312,500	$43,605,000
Transport Costs per Turbine		$28,438	$85,800	$155,112	$506,250	$872,100
Transport Cost per kW	$/kW	$32.92	$57.00	$62.12	$146.49	$175.25
Transport Costs per Swept Area	$/sq. m	$14.48	$25.08	$27.33	$64.46	$77.11
Hub						
Height	m	2.25	3.2	3.8	3.8	4.2
Diameter	m	2.25	3.8	4	4	4.5
Mass	kg	3816	12516	22,457	34,136	54,604
Transport Mass	metric tons	4	13	22	34	55
Transport Volume	cu. M	9	36	48	48	67
Cost per Transport Unit	$	$2,237	$9,073	$11,938	$11,938	$16,700
Hubs per Transport Unit	each	1	1	1	1	1
Number of Transport Units		50	50	50	50	50
Total Transport Costs		$111,827	$453,646	$596,903	$596,903	$834,976
Transport Costs per Turbine		$2,237	$9,073	$11,938	$11,938	$16,700
Transport Cost per kW	$/kW	$2.59	$6.03	$4.78	$3.45	$3.36
Transport Costs per Swept Area	$/sq. m	$1.14	$2.65	$2.10	$1.52	$1.48
Nacelle						
Length	m	6	9	10	12	15
Width	m	3	3.5	4	4	4.5
Height	m	3	3.5	4	4	4.5
Total Nacelle Mass	kg	31,081	60,517	111,065	164,049	254,102
Transport Mass	metric tons	31	61	111	164	254
Transport Volume	cu. M	54	110	160	192	304
Cost per Transport Unit	$	$13,500	$27,563	$40,000	$48,000	$75,938
Nacelles per Transport Unit	each	1	1	1	1	1
Number of Transport Units		50	50	50	50	50
Total Transport Costs		$675,000	$1,378,125	$2,000,000	$2,400,000	$3,796,875
Transport Costs per Turbine		$13,500	$27,563	$40,000	$48,000	$75,938
Transport Cost per kW	$/kW	$15.63	$18.31	$16.02	$13.89	$15.26
Transport Costs per Swept Area	$/sq. m	$6.88	$8.06	$7.05	$6.11	$6.71

		750	1500	2500	3500	5000
Rotor Diameter	m	50	66	85	100	120
Swept Area	sq. m	1963	3421	5675	7854	11310
Rated Power	kW	864	1505	2497	3456	4976
Tower						
Total Cost per Turbine		$416,786	$957,889	$2,045,111	$3,329,230	$5,751,454
Transport Cost per kW	$/kW	$482	$636	$819	$963	$1,156
Transport Costs per Swept Area	$/sq. m	$212	$280	$360	$424	$509
Section 1 (Base)						
Length	m	21.67	21.45	22.10	21.67	22.29
Base Diameter	m	3.74	4.94	6.36	7.48	8.97
Diameter 2	m	3.12	4.32	5.72	6.85	8.33
Mass	kg	28,642	51,574	90,403	124,764	187,016
Transport Mass	metric tons	29	52	90	125	187
Transport Volume	cu. M	803	1445	2534	3497	5241
Cost per Transport Unit	$	$200,675	$361,346	$633,400	$874,143	$1,310,306
Section 2						
Length	m	21.67	21.45	22.10	21.67	22.29
Diameter 1	m	3.12	4.32	5.72	6.85	8.33
Diameter 2	m	2.49	3.70	5.08	6.23	7.69
Mass	kg	19,199	38,757	72,389	104,022	160,349
Transport Mass	metric tons	19	39	72	104	160
Transport Volume	cu. M	538	1086	2029	2915	4494
Cost per Transport Unit	$	$134,518	$271,544	$507,188	$728,819	$1,123,462
Section 3						
Length	m	21.67	21.45	22.10	21.67	22.29
Diameter 1	m	2.49	3.70	5.08	6.23	7.69
Diameter 2	m	1.87	3.09	4.45	5.61	7.05
Mass	kg	11,646	27,771	56,377	85,166	135,732
Transport Mass	metric tons	12	28	56	85	136
Transport Volume	cu. M	326	778	1580	2387	3804
Cost per Transport Unit	$	$81,593	$194,571	$394,999	$596,707	$950,990
Section 4						
Length	m		21.45	22.10	21.67	22.29
Diameter 1	m		3.09	4.45	5.61	7.05
Diameter 2	m		2.47	3.81	4.98	6.41
Mass	kg		18,615	42,366	68,196	113,167
Transport Mass	metric tons		19	42	68	113
Transport Volume	cu. M		522	1187	1911	3172
Cost per Transport Unit	$		$130,427	$296,833	$477,806	$792,891
Section 5						
Length	m			22.10	21.67	22.29
Diameter 1	m			3.81	4.98	6.41
Diameter 2	m			3.18	4.36	5.77
Mass	kg			30,357	53,111	92,653
Transport Mass	metric tons			30	53	93
Transport Volume	cu. M			851	1488	2597
Cost per Transport Unit	$			$212,692	$372,116	$649,164
Section 6						
Length	m				21.67	22.29
Diameter 1	m				4.36	5.77
Diameter 2	m				3.74	5.13
Mass	kg				39,912	74,191
Transport Mass	metric tons				40	74
Transport Volume	cu. M				1119	2079
Cost per Transport Unit	$				$279,638	$519,811
Section 7						
Length	m					22.29
Diameter 1	m					5.13
Diameter 2	m					4.49
Mass	kg					57,780
Transport Mass	metric tons					58
Transport Volume	cu. M					1619
Cost per Transport Unit	$					$404,830

Appendix I
Scenario 1

Number of People in Crew:	10	100%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m)		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers	54	$2,176		62	$2,498		75	$3,023		96	$3,869		142	$5,723	
2. Rig & Set Tower Sections	64	$2,580		132	$5,320		243	$9,793		354	$14,265		619	$24,810	
3. Grout and Torque Bases	37	$1,492	$450	40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
4. Assemble Rotors, Blades and Nacelle	43	$1,733	$150	50	$2,015	$250	74	$2,982	$500	86	$3,465	$700	124	$4,998	$1,000
5. Rig & Set Nacelle and Blades	41	$1,667		57	$2,317		133	$6,488		174	$8,550		280	$13,370	
6. Install Safety Equipment	9	$363		12	$484		20	$806		24	$968		36	$1,450	
7. General Conditions		$2,172	$5,713		$2,172	$5,713		$2,459	$10,789		$2,459	$10,789		$8,729	$20,941
8. Margin @ 10%		$1,218	$631		$1,642	$681		$2,793	$1,224		$3,640	$1,261		$6,259	$2,359
Subtotal Per Turbine	**248**	**$13,401**	**$6,944**	**353**	**$18,060**	**$7,494**	**604**	**$30,721**	**$13,463**	**804**	**$40,037**	**$13,870**	**1288**	**$68,844**	**$25,950**
Percent of Total		66%	34%		71%	29%		70%	30%		74%	26%		73%	27%
Project Total (50 Turbines)	**12400**	**$670,046**	**$347,215**	**17650**	**$903,023**	**$374,715**	**30200**	**$1,536,038**	**$673,145**	**40200**	**$2,001,866**	**$693,495**	**64400**	**$3,442,179**	**$1,297,505**
Total All Costs		**$1,017,261**			**$1,277,738**			**$2,209,183**			**$2,695,361**			**$4,739,684**	
Total Cost per Turbine		**$20,345**			**$25,555**			**$44,184**			**$53,907**			**$94,794**	
Estimated Assembly Rate - Items 2,5 (Hours)		**105**			**189**			**376**			**528**			**899**	
Estimated Assembly Rate - Items 2,5 (Days)		**1.05**			**1.89**			**3.76**			**5.28**			**9.0**	
Total Costs/kW		$23.55			$16.98			$17.70			$15.60			$19.05	
Labor Costs/kW		$15.51			$12.00			$12.30			$11.59			$13.83	
Equip.Mater Costs/kW		$8.04			$4.98			$5.39			$4.01			$5.21	
Total Cost/Swept Area		$10.36			$7.47			$7.79			$6.86			$8.38	
Man-Hours/Swept Area		0.13			0.10			0.11			0.10			0.11	
Labor Costs/Swept Area		$6.83			$5.28			$5.41			$5.10			$6.09	
Equip, Mater Costs/Swept Area		$3.54			$2.19			$2.37			$1.77			$2.29	
Total Costs/Hub Height		$313			$298			$400			$415			$608	
Labor Costs/Hub Height		$206			$210			$278			$308			$441	
Equip.Mater Costs/Hub Height		$107			$87			$122			$107			$166	
Item 1 Hourly Rates	$40.30			$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates	$40.31			$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates	$40.32			$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates	$40.30			$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates	$40.65			$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates	$40.33			$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate	$53.61			$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor	16%			14%			10%			10%			8%		
Item 2 Percent of Labor	19%			29%			32%			36%			36%		
Item 3 Percent of Labor	11%			9%			8%			7%			5%		
Item 4 Percent of Labor	13%			11%			10%			9%			7%		
Item 5 Percent of Labor	12%			13%			21%			21%			19%		
Item 6 Percent of Labor	3%			3%			3%			2%			2%		
Item 7 Percent of Labor	16%			12%			8%			6%			13%		
Item 8 Percent of Labor	9%			9%			9%			9%			9%		

Number of People in Crew:	10	75%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers	24	$840		40	$1,400		75	$2,625		96	$3,360		142	$4,970	
2. Rig & Set Tower Sections	42	$1,470		60	$2,100		110	$3,866		161	$5,645		282	$9,878	
3. Grout and Torque Bases	32	$1,120	$450	40	$1,400	$850	59	$2,065	$950	70	$2,450	$1,120	87	$3,045	$1,650
4. Assemble Rotors, Blades and Nacelle	30	$1,050	$150	50	$1,750	$250	74	$2,590	$500	86	$3,010	$700	124	$4,340	$1,000
5. Rig & Set Nacelle and Blades	16	$560		22	$778		52	$2,528		68	$3,335		109	$5,219	
6. Install Safety Equipment	9	$315		12	$420		20	$700		24	$840		36	$1,260	
7. General Conditions		$1,629	$4,285		$1,629	$4,285		$1,844	$8,092		$1,844	$8,092		$6,546	$15,706
8. Margin @ 10%		$698	$488		$948	$538		$1,622	$954		$2,048	$991		$3,526	$1,836
Subtotal Per Turbine	**153**	**$7,682**	**$5,373**	**224**	**$10,425**	**$5,923**	**390**	**$17,840**	**$10,496**	**505**	**$22,533**	**$10,903**	**781**	**$38,783**	**$20,191**
Percent of Total		59%	41%		64%	36%		63%	37%		67%	33%		66%	34%
Project Total (50 Turbines)	**7650**	**$384,120**	**$268,661**	**11212**	**$521,257**	**$296,161**	**19514**	**$891,997**	**$524,796**	**25258**	**$1,126,632**	**$545,146**	**39026**	**$1,939,157**	**$1,009,566**
Total All Costs		**$652,781**			**$817,418**			**$1,416,794**			**$1,671,779**			**$2,948,723**	
Total Cost per Turbine		**$13,056**			**$16,348**			**$28,336**			**$33,436**			**$58,974**	
Estimated Assembly Rate - Items 2,5 (Hours)		**58**			**82**			**162**			**229**			**392**	
Estimated Assembly Rate - Items 2,5 (Days)		**0.58**			**0.82**			**1.62**			**2.29**			**3.92**	
Total Costs/kW		$15.11			$10.86			$11.35			$9.68			$11.85	
Labor Costs/kW		$8.89			$6.93			$7.15			$6.52			$7.79	
Equip.Mater Costs/kW		$6.22			$3.93			$4.20			$3.16			$4.06	
Total Cost/Swept Area		$6.65			$4.78			$4.99			$4.26			$5.21	
Man-Hours/Swept Area		0.08			0.07			0.07			0.06			0.07	
Labor Costs/Swept Area		$3.91			$3.05			$3.14			$2.87			$3.43	
Equip, Mater Costs/Swept Area		$2.74			$1.73			$1.85			$1.39			$1.79	
Total Costs/Hub Height		$201			$191			$256			$257			$378	
Labor Costs/Hub Height		$118			$122			$161			$173			$249	
Equip.Mater Costs/Hub Height		$83			$69			$95			$84			$129	
Item 1 Hourly Rates	$35.00			$35.00			$35.00			$35.00			$35.00		
Item 2 Hourly Rates	$35.00			$35.00			$35.00			$35.00			$35.00		
Item 3 Hourly Rates	$35.00			$35.00			$35.00			$35.00			$35.00		
Item 4 Hourly Rates	$35.00			$35.00			$35.00			$35.00			$35.00		
Item 5 Hourly Rates	$35.00			$35.00			$48.78			$49.14			$47.75		
Item 6 Hourly Rates	$35.00			$35.00			$35.00			$35.00			$35.00		
Combined Hourly Rate															
Item 1 Percent of Labor	11%			13%			15%			15%			13%		
Item 2 Percent of Labor	19%			20%			22%			25%			25%		
Item 3 Percent of Labor	15%			13%			12%			11%			8%		
Item 4 Percent of Labor	14%			17%			15%			13%			11%		
Item 5 Percent of Labor	7%			7%			14%			15%			13%		
Item 6 Percent of Labor	4%			4%			4%			4%			3%		
Item 7 Percent of Labor	21%			16%			10%			8%			17%		
Item 8 Percent of Labor	9%			9%			9%			9%			9%		

Number of People in Crew:	10	105%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers	54	$2,176		64	$2,579		75	$3,023		96	$3,869		142	$5,723	
2. Rig & Set Tower Sections	67	$2,701		138	$5,569		254	$10,253		371	$14,970		687	$27,693	
3. Grout and Torque Bases	37	$1,492	$450	40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
4. Assemble Rotors, Blades and Nacelle	43	$1,733	$150	50	$2,015	$250	74	$2,982	$500	86	$3,465	$700	124	$4,998	$1,000
5. Rig & Set Nacelle and Blades	48	$1,951		67	$2,712		155	$7,583		204	$10,006		348	$16,628	
6. Install Safety Equipment	9	$363		12	$484		20	$806		24	$968		36	$1,450	
7. General Conditions		$2,281	$5,999		$2,281	$5,999		$2,582	$11,328		$2,582	$11,328		$9,165	$21,988
8. Margin @ 10%		$1,270	$660		$1,725	$710		$2,961	$1,278		$3,868	$1,315		$6,916	$2,464
Subtotal Per Turbine	**258**	**$13,966**	**$7,259**	**371**	**$18,978**	**$7,809**	**638**	**$32,567**	**$14,056**	**851**	**$42,550**	**$14,463**	**1424**	**$76,079**	**$27,102**
Percent of Total		66%	34%		71%	29%		70%	30%		75%	25%		74%	26%
Project Total (50 Turbines)	**12900**	**$698,321**	**$362,926**	**18545.38**	**$948,875**	**$390,426**	**31893**	**$1,628,329**	**$702,815**	**42554**	**$2,127,513**	**$723,165**	**71219**	**$3,803,962**	**$1,355,093**
Total All Costs		**$1,061,246**			**$1,339,301**			**$2,331,143**			**$2,850,678**			**$5,159,055**	
Total Cost per Turbine		**$21,225**			**$26,786**			**$46,623**			**$57,014**			**$103,181**	
Estimated Assembly Rate - Items 2,5 (Hours)		**115**			**205**			**410**			**575**			**1,035**	
Estimated Assembly Rate - Items 2,5 (Days)		**1.15**			**2.05**			**4.10**			**5.75**			**10.35**	
Total Costs/kW		$24.57			$17.79			$18.67			$16.50			$20.73	
Labor Costs/kW		$16.17			$12.61			$13.04			$12.31			$15.29	
Equip.Mater Costs/kW		$8.40			$5.19			$5.63			$4.19			$5.45	
Total Cost/Swept Area		$10.81			$7.83			$8.22			$7.26			$9.12	
Man-Hours/Swept Area		0.13			0.11			0.11			0.11			0.13	
Labor Costs/Swept Area		$7.11			$5.55			$5.74			$5.42			$6.73	
Equip, Mater Costs/Swept Area		$3.70			$2.28			$2.48			$1.84			$2.40	
Total Costs/Hub Height		$327			$312			$422			$439			$661	
Labor Costs/Hub Height		$215			$221			$295			$327			$488	
Equip.Mater Costs/Hub Height		$112			$91			$127			$111			$174	
Item 1 Hourly Rates	$40.30			$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates	$40.31			$40.30			$40.30			$40.30			$40.30		
Item 3 Hourly Rates	$40.32			$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates	$40.30			$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates	$40.65			$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates	$40.33			$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate	$53.61			$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor	16%			14%			9%			9%			8%		
Item 2 Percent of Labor	19%			29%			31%			35%			36%		
Item 3 Percent of Labor	11%			8%			7%			7%			5%		
Item 4 Percent of Labor	12%			11%			9%			8%			7%		
Item 5 Percent of Labor	14%			14%			23%			24%			22%		
Item 6 Percent of Labor	3%			3%			2%			2%			2%		
Item 7 Percent of Labor	16%			12%			8%			6%			12%		
Item 8 Percent of Labor	9%			9%			9%			9%			9%		

Turbine Class:	750					
Rotor Diameter:	50					
Crane Type:	4100 S1			**4600 S4**		
	Min	Avg	Max	Min	Avg	Max
Crane Crew Assembly Labor Costs/Turbine	$754	$1,365	$1,495	$754	$1,365	$1,495
Crane Crew Relocation Labor Costs/Turbine	$780	$780	$780	$780	$780	$780
Crane Rental Costs During Assembly and Reloc	$900	$952	$1,010	$1,920	$2,031	$2,154
Meals and Lodging/Turbine	$177	$248	$263	$177	$248	$263
Fuel Cost/Turbine	$65	$91	$96	$74	$103	$109
Cribbing Costs/Turbine	$131	$131	$131	$190	$190	$190
Mob/Demob Costs/Turbine	$1,328	$1,328	$1,328	$2,477	$2,477	$2,477
Total Crane and Crew Costs/Turbine	**$4,135**	**$4,894**	**$5,102**	**$6,371**	**$7,193**	**$7,467**
Total Crane Costs (50 Turbines)	**$206,749**	**$244,713**	**$255,122**	**$318,570**	**$359,652**	**$373,369**
Costs/kW	$4.79	$5.67	$5.91	$7.37	$8.33	$8.64
Costs/Swept Area	$2.11	$2.49	$2.60	$3.24	$3.66	$3.80

Turbine Class:	1500						
Rotor Diameter:	66						
Crane Type:	4600 S5			What If	**LTL-600**		
	Min	Avg	Max	Avg	Min	Avg	Max
Crane Crew Assembly Labor Costs/Turbine	$1,066	$2,457	$2,665	$2,457	$1,599	$3,686	$3,998
Crane Crew Relocation Labor Costs/Turbine	$780	$780	$780	$1,040	$1,560	$1,560	$1,560
Crane Rental Costs During Assembly and Reloc	$2,250	$3,591	$3,822	$7,242	$5,608	$9,312	$9,865
Meals and Lodging/Turbine	$213	$374	$398	$404	$365	$605	$641
Fuel Cost/Turbine	$89	$156	$166	$168	$263	$437	$463
Cribbing Costs/Turbine	$595	$595	$595	$595	$808	$808	$808
Mob/Demob Costs/Turbine	$2,757	$2,757	$2,757	$4,225	$8,302	$8,302	$8,302
Total Crane and Crew Costs/Turbine	**$7,749**	**$10,709**	**$11,182**	**$16,131**	**$18,504**	**$24,709**	**$25,637**
Total Crane Costs (50 Turbines)	**$387,470**	**$535,456**	**$559,095**	**$806,533**	**$925,188**	**$1,235,437**	**$1,281,829**
Costs/kW	$5.15	$7.11	$7.43	$10.72	$12.29	$16.41	$17.03
Costs/Swept Area	$2.27	$3.13	$3.27	$4.71	$5.41	$7.22	$7.49

Turbine Class:	2500			3500					
Rotor Diameter:	85			100					
Crane Type:	**LTL-850**			LTL-1000			**LTL-1100**		
	Min	**Avg**	**Max**	Min	Avg	Max	Min	Avg	Max
Crane Crew Assembly Labor Costs/Turbine	$3,159	$7,332	$7,995	$4,466	$10,296	$11,213	$4,466	$10,296	$11,213
Crane Crew Relocation Labor Costs/Turbine	$2,730	$2,730	$2,730	$4,095	$4,095	$4,095	$4,875	$4,875	$4,875
Crane Rental Costs During Assembly and Reloc	$10,841	$18,523	$19,744	$18,995	$31,933	$33,966	$23,213	$37,703	$39,981
Meals and Lodging/Turbine	$680	$1,161	$1,238	$988	$1,661	$1,766	$1,078	$1,751	$1,856
Fuel Cost/Turbine	$491	$839	$894	$768	$1,292	$1,374	$838	$1,362	$1,444
Cribbing Costs/Turbine	$538	$538	$538	$808	$808	$808	$943	$943	$943
Mob/Demob Costs/Turbine	$9,695	$9,695	$9,695	$19,522	$19,522	$19,522	$22,141	$22,141	$22,141
Total Crane and Crew Costs/Turbine	**$28,132**	**$40,817**	**$42,832**	**$49,642**	**$69,606**	**$72,744**	**$57,553**	**$79,069**	**$82,451**
Total Crane Costs (50 Turbines)	**$1,406,616**	**$2,040,831**	**$2,141,594**	**$2,482,078**	**$3,480,278**	**$3,637,185**	**$2,877,640**	**$3,953,465**	**$4,122,575**
Costs/kW	$11.27	$16.35	$17.15	$14.36	$20.14	$21.05	$16.65	$22.88	$23.86
Costs/Swept Area	$4.96	$7.19	$7.55	$6.32	$8.86	$9.26	$7.33	$10.07	$10.50

Turbine Class:	5000					
Rotor Diameter:	120					
Crane Type:	LTL-1100			**LTL-1200**		
	Min	Avg	Max	Min	Avg	Max
Crane Crew Assembly Labor Costs/Turbine	$7,644	$17,550	$20,183	$7,644	$17,550	$20,183
Crane Crew Relocation Labor Costs/Turbine	$4,875	$4,875	$4,875	$6,435	$6,435	$6,435
Crane Rental Costs During Assembly and Reloc	$29,960	$53,667	$59,967	$42,117	$71,750	$79,625
Meals and Lodging/Turbine	$1,445	$2,588	$2,891	$1,625	$2,768	$3,071
Fuel Cost/Turbine	$1,124	$2,013	$2,249	$1,354	$2,306	$2,559
Cribbing Costs/Turbine	$943	$943	$943	$943	$943	$943
Mob/Demob Costs/Turbine	$22,650	$22,650	$22,650	$32,116	$32,116	$32,116
Total Crane and Crew Costs/Turbine	**$68,639**	**$104,284**	**$113,756**	**$92,232**	**$133,867**	**$144,931**
Total Crane Costs (50 Turbines)	**$3,431,966**	**$5,214,199**	**$5,687,824**	**$4,611,602**	**$6,693,344**	**$7,246,563**
Costs/kW	$13.79	$20.96	$22.86	$18.53	$26.90	$29.12
Costs/Swept Area	$6.07	$9.22	$10.06	$8.16	$11.84	$12.81

Initial Assumptions	Turbine Assembly	Crane Assembly								
Work Hours/Day	10	8								
Number of Days/Wk	6	5								
Number of Weeks/Year	52	52								
Number of Weeks/Month	4.3333	4.4000								
Number of Days/Month	26	22								
Number of Hours/Month	260	176								
Number of Turbines	50									
Turbine Rating (kW)	750			1500		2500	3500		5000	
Crane Type	4100 S1	**4600 S4**	4600 S5	what if	**LTL-600**	**LTL-850**	LTL-1000	**LTL-1100**	LTL-1100	**LTL-1200**
Monthly Crane Costs during turbine assembly (60hr wk)	$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
Monthly crane costs other time	$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
6 Month Rental Costs	$14,000	$29,867	$35,000	$65,333	$84,000	$93,333	$116,667	$130,667	$130,667	$163,333
9 Month Rental Costs	$13,500	$28,800	$33,750	$63,000	$81,000	$90,000	$112,500	$126,000	$126,000	$157,500
12 Month Rental Costs	$13,000	$27,733	$32,500	$60,667	$78,000	$86,667	$108,333	$121,333	$121,333	$151,667
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)										
Number of People in Crew	10	10	10	10	10	10	10	10	10	10
Number of Crews	1	1	1	1	1	1	1	1	1	1
Man Hours/Day	100	100	100	100	100	100	100	100	100	100
Number of Man Hours/Wk	600	600	600	600	600	600	600	600	600	600
Crane Assembly Rate Days/Turbine	1.05	1.05	1.89	1.89	1.89	3.76	5.28	5.28	9	9
2. Crane Crew Information - During Turbine Assembly										
Number of People in Crane Crew	2	2	2	2	3	3	3	3	3	3
Number of Cranes and Crew	1	1	1	1	1	1	1	1	1	1
Number of Turbines/Crane	50	50	50	50	50	50	50	50	50	50
Man Hours/Day	20	20	20	20	30	30	30	30	30	30
Estimated Crane Crew Man Hours/Turbine	21	21	37.8	37.8	56.7	112.8	158.4	158.4	270	270
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65	$65	$65	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$1,365	$1,365	$2,457	$2,457	$3,686	$7,332	$10,296	$10,296	$17,550	$17,550
3. Crane Relocation Information										
Estimated Relocation Hours/Turbine	6	6	6	8	8	14	21	25	25	33
Total Relocation Hours	300	300	300	400	400	700	1050	1250	1250	1650
Total Relocation Hours/Crane	300	300	300	400	400	700	1050	1250	1250	1650
Relocation Days/Crane	30	30	30	40	40	70	105	125	125	165
Estimated Relocation Days/Turbine	0.6	0.6	0.6	0.8	0.8	1.4	2.1	2.5	2.5	3.3
Crane Crew Relocation Man Hours/Turbine	12.0	12.0	12.0	16.0	24.0	42.0	63.0	75.0	75.0	99.0
Crane Crew Relocation Labor Costs/Turbine	$780	$780	$780	$1,040	$1,560	$2,730	$4,095	$4,875	$4,875	$6,435
Crane Costs During Relocation/Turbine	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
3. Totals										
Total Number of Crane Assembly Days/Turbine	1.65	1.65	2.49	2.69	2.69	5.16	7.38	7.78	11.50	12.30
Total Number of Days Required:	83	83	125	135	135	258	369	389	575	615
Total Number of Weeks Required	13.8	13.8	20.8	22.4	22.4	43.0	61.5	64.8	95.8	102.5
Installed kW per Day	455	455	602	0	558	484	474	450	304	407
Total Number of Months for Assembly	**3.2**	**3.2**	**4.8**	**5.2**	**5.2**	**9.9**	**14.2**	**15.0**	**22.1**	**23.7**
3 Month Min Crane Rental Costs	$45,000	$96,000	$112,500	$210,000	$270,000	$300,000	$375,000	$420,000	$420,000	$525,000
Total Crane Rental Charges	$47,596	$101,538	$179,567	$362,115	$465,577	$926,154	$1,596,635	$1,885,154	$2,683,333	$3,587,500
Crane Rental Costs/Turbine	$952	$2,031	$3,591	$7,242	$9,312	$18,523	$31,933	$37,703	$53,667	$71,750
4. Material/Supplies/Incidental Crane Costs										
Meals and Lodging/Person/Day	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75
Number of Person-Days	165	165	249	269	403.5	774	1107	1167	1725	1845
Total Meals and Lodging Costs	$12,375	$12,375	$18,675	$20,175	$30,263	$58,050	$83,025	$87,525	$129,375	$138,375
Meals and Lodging/Turbine	$248	$248	$374	$404	$605	$1,161	$1,661	$1,751	$2,588	$2,768
5. Fuel										
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	250	250	250	650	650	700	700	700	750
Total Cost of Fuel	$4,538	$5,156	$7,781	$8,406	$21,856	$41,925	$64,575	$68,075	$100,625	$115,313
Fuel Cost/Turbine	$91	$103	$156	$168	$437	$839	$1,292	$1,362	$2,013	$2,306
6. Cribbing										
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	3800	11900	11900	16150	10750	16150	18850	18850	18850
Cribbing Costs/Turbine	$131	$190	$595	$595	$808	$538	$808	$943	$943	$943
7. Mobilization and Demobilization										
Crane Assembly and Disassembly Hours	24	48	48	80	160	192	360	360	360	480
Lampson Supervisor Hours	24	48	48	80	160	192	360	360	360	480
Lampson Supervisor Hourly Cost	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4	6	6	8	8	8	10
Man Hours for Iron Workers	96	192	192	320	960	1152	2880	2880	2880	4800
Iron Worker Hourly Cost	$65	$65	$65	$65	$65	$65	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.3	0.3	0.5	0.9	1.1	2.0	2.0	2.0	2.7
Crane Rental Cost	$2,045	$8,727	$10,227	$31,818	$81,818	$109,091	$255,682	$286,364	$286,364	$477,273
Total Labor Costs	$8,040	$16,080	$16,080	$26,800	$74,400	$89,280	$214,200	$214,200	$214,200	$348,000
Truck Crane 1 Hourly Cost	$185	$185	$185	$185	$185	$185	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325	$325	$350	$350	$350	$350	$400
Truck Crane 3 Hourly Costs								$185	$185	$185
Total Truck Crane Costs	$12,240	$24,480	$24,480	$40,800	$81,600	$102,720	$192,600	$259,200	$259,200	$369,600
Total Transportation Freight in/out	$40,000	$60,000	$70,000	$80,000	$120,000	$120,000	$200,000	$220,000	$220,000	$220,000
Transport Days in/out	6	10	10	10	14	14	20	20	24	24
Transport Hours in/out	48	80	80	80	112	112	160	160	192	192
Crane Rental During Transport	$4,091	$14,545	$17,045	$31,818	$57,273	$63,636	$113,636	$127,273	$152,727	$190,909
SubTotal	$66,416	$123,833	$137,833	$211,236	$415,091	$484,727	$976,118	$1,107,036	$1,132,491	$1,605,782
Mob/Demob Costs/Turbine	$1,328	$2,477	$2,757	$4,225	$8,302	$9,695	$19,522	$22,141	$22,650	$32,116
Crane assembly costs	$22,325	$49,287	$50,787	$99,418	$237,818	$301,091	$662,482	$759,764	$759,764	$1,194,873
Total Crane Costs	$244,713	$359,652	$535,456	$806,533	$1,235,437	$2,040,831	$3,480,278	$3,953,465	$5,214,199	$6,693,344
Total Crane time (months)	3.72	4.17	5.79	6.54	7.63	12.74	19.19	19.96	27.30	30.20
Loaded Hourly Crane Costs	$373.91	$489.68	$525.59	$701.05	$920.28	$910.09	$1,030.32	$1,125.31	$1,085.32	$1,259.31

Initial Assumptions	Turbine Assembly	Crane Assembly								
Work Hours/Day	10	8								
Number of Days/Wk	6	5								
Number of Weeks/Year	52	52								
Number of Weeks/Month	4.3333	4.4000								
Number of Days/Month	26	22								
Number of Hours/Month	260	176								
Number of Turbines	50									
Turbine Rating (kW)	750			1500		2500	3500		5000	
Crane Type	4100 S1	**4600 S4**	4600 S5	what if	**LTL-600**	**LTL-850**	LTL-1000	**LTL-1100**	LTL-1100	**LTL-1200**
Monthly Crane Costs during turbine assembly (60hr wk)	$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
Monthly crane costs other time	$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
6 Month Rental Costs	$14,000	$29,867	$35,000	$65,333	$84,000	$93,333	$116,667	$130,667	$130,667	$163,333
9 Month Rental Costs	$13,500	$28,800	$33,750	$63,000	$81,000	$90,000	$112,500	$126,000	$126,000	$157,500
12 Month Rental Costs	$13,000	$27,733	$32,500	$60,667	$78,000	$86,667	$108,333	$121,333	$121,333	$151,667
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)										
Number of People in Crew	10	10	10	10	10	10	10	10	10	10
Number of Crews	1	1	1	1	1	1	1	1	1	1
Man Hours/Day	100	100	100	100	100	100	100	100	100	100
Number of Man Hours/Wk	600	600	600	600	600	600	600	600	600	600
Crane Assembly Rate Days/Turbine	0.58	0.58	0.82	0.82	0.82	1.62	2.29	2.29	3.92	3.92
2. Crane Crew Information - During Turbine Assembly										
Number of People in Crane Crew	2	2	2	2	3	3	3	3	3	3
Number of Cranes and Crew	1	1	1	1	1	1	1	1	1	1
Number of Turbines/Crane	50	50	50	50	50	50	50	50	50	50
Man Hours/Day	20	20	20	20	30	30	30	30	30	30
Estimated Crane Crew Man Hours/Turbine	11.6	11.6	16.4	16.4	24.6	48.6	68.7	68.7	117.6	117.6
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65	$65	$65	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$754	$754	$1,066	$1,066	$1,599	$3,159	$4,466	$4,466	$7,644	$7,644
3. Crane Relocation Information										
Estimated Relocation Hours/Turbine	6	6	6	8	8	14	21	25	25	33
Total Relocation Hours	300	300	300	400	400	700	1050	1250	1250	1650
Total Relocation Hours/Crane	300	300	300	400	400	700	1050	1250	1250	1650
Relocation Days/Crane	30	30	30	40	40	70	105	125	125	165
Estimated Relocation Days/Turbine	0.6	0.6	0.6	0.8	0.8	1.4	2.1	2.5	2.5	3.3
Crane Crew Relocation Man Hours/Turbine	12.0	12.0	12.0	16.0	24.0	42.0	63.0	75.0	75.0	99.0
Crane Crew Relocation Labor Costs/Turbine	$780	$780	$780	$1,040	$1,560	$2,730	$4,095	$4,875	$4,875	$6,435
Crane Costs During Relocation/Turbine	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
3. Totals										
Total Number of Crane Assembly Days/Turbine	1.18	1.18	1.42	1.62	1.62	3.02	4.39	4.79	6.42	7.22
Total Number of Days Required:	59	59	71	81	81	151	220	240	321	361
Total Number of Weeks Required	9.8	9.8	11.8	13.5	13.5	25.2	36.6	39.9	53.5	60.2
Installed kW per Day	636	636	1056	0	926	828	797	731	545	693
Total Number of Months for Assembly	**2.3**	**2.3**	**2.7**	**3.1**	**3.1**	**5.8**	**8.4**	**9.2**	**12.3**	**13.9**
3 Month Min Crane Rental Costs	$45,000	$96,000	$112,500	$210,000	$270,000	$300,000	$375,000	$420,000	$420,000	$525,000
Total Crane Rental Charges	$34,038	$72,615	$102,404	$218,077	$280,385	$542,051	$949,760	$1,160,654	$1,498,000	$2,105,833
Crane Rental Costs/Turbine	$900	$1,920	$2,250	$4,362	$5,608	$10,841	$18,995	$23,213	$29,960	$42,117
4. Material/Supplies/Incidental Crane Costs										
Meals and Lodging/Person/Day	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75
Number of Person-Days	118	118	142	162	243	453	658.5	718.5	963	1083
Total Meals and Lodging Costs	$8,850	$8,850	$10,650	$12,150	$18,225	$33,975	$49,388	$53,888	$72,225	$81,225
Meals and Lodging/Turbine	$177	$177	$213	$243	$365	$680	$988	$1,078	$1,445	$1,625
5. Fuel										
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	250	250	250	650	650	700	700	700	750
Total Cost of Fuel	$3,245	$3,688	$4,438	$5,063	$13,163	$24,538	$38,413	$41,913	$56,175	$67,688
Fuel Cost/Turbine	$65	$74	$89	$101	$263	$491	$768	$838	$1,124	$1,354
6. Cribbing										
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	3800	11900	11900	16150	10750	16150	18850	18850	18850
Cribbing Costs/Turbine	$131	$190	$595	$595	$808	$538	$808	$943	$943	$943
7. Mobilization and Demobilization										
Crane Assembly and Disassembly Hours	24	48	48	80	160	192	360	360	360	480
Lampson Supervisor Hours	24	48	48	80	160	192	360	360	360	480
Lampson Supervisor Hourly Cost	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4	6	6	8	8	8	10
Man Hours for Iron Workers	96	192	192	320	960	1152	2880	2880	2880	4800
Iron Worker Hourly Cost	$65	$65	$65	$65	$65	$65	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.3	0.3	0.5	0.9	1.1	2.0	2.0	2.0	2.7
Crane Rental Cost	$2,045	$8,727	$10,227	$31,818	$81,818	$109,091	$255,682	$286,364	$286,364	$477,273
Total Labor Costs	$8,040	$16,080	$16,080	$26,800	$74,400	$89,280	$214,200	$214,200	$214,200	$348,000
Truck Crane 1 Hourly Cost	$185	$185	$185	$185	$185	$185	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325	$325	$350	$350	$350	$350	$400
Truck Crane 3 Hourly Costs								$185	$185	$185
Total Truck Crane Costs	$12,240	$24,480	$24,480	$40,800	$81,600	$102,720	$192,600	$259,200	$259,200	$369,600
Total Transportation Freight in/out	$40,000	$60,000	$70,000	$80,000	$120,000	$120,000	$200,000	$220,000	$220,000	$220,000
Transport Days in/out	6	10	10	10	14	14	20	20	24	24
Transport Hours in/out	48	80	80	80	112	112	160	160	192	192
Crane Rental During Transport	$4,091	$14,545	$17,045	$31,818	$57,273	$63,636	$113,636	$127,273	$152,727	$190,909
SubTotal	$66,416	$123,833	$137,833	$211,236	$415,091	$484,727	$976,118	$1,107,036	$1,132,491	$1,605,782
Mob/Demob Costs/Turbine	$1,328	$2,477	$2,757	$4,225	$8,302	$9,695	$19,522	$22,141	$22,650	$32,116

Initial Assumptions	Turbine Assembly	Crane Assembly								
Work Hours/Day	10	8								
Number of Days/Wk	6	5								
Number of Weeks/Year	52	52								
Number of Weeks/Month	4.3333	4.4000								
Number of Days/Month	26	22								
Number of Hours/Month	260	176								
Number of Turbines	50									
Turbine Rating (kW)	750			1500		2500	3500		5000	
Crane Type	4100 S1	**4600 S4**	4600 S5	what if	**LTL-600**	**LTL-850**	LTL-1000	**LTL-1100**	LTL-1100	**LTL-1200**
Monthly Crane Costs during turbine assembly (60hr wk)	$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
Monthly crane costs other time	$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
6 Month Rental Costs	$14,000	$29,867	$35,000	$65,333	$84,000	$93,333	$116,667	$130,667	$130,667	$163,333
9 Month Rental Costs	$13,500	$28,800	$33,750	$63,000	$81,000	$90,000	$112,500	$126,000	$126,000	$157,500
12 Month Rental Costs	$13,000	$27,733	$32,500	$60,667	$78,000	$86,667	$108,333	$121,333	$121,333	$151,667
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)										
Number of People in Crew	10	10	10	10	10	10	10	10	10	10
Number of Crews	1	1	1	1	1	1	1	1	1	1
Man Hours/Day	100	100	100	100	100	100	100	100	100	100
Number of Man Hours/Wk	600	600	600	600	600	600	600	600	600	600
Crane Assembly Rate Days/Turbine	1.15	1.15	2.05	2.05	2.05	4.1	5.75	5.75	10.35	10.35
2. Crane Crew Information - During Turbine Assembly										
Number of People in Crane Crew	2	2	2	2	3	3	3	3	3	3
Number of Cranes and Crew	1	1	1	1	1	1	1	1	1	1
Number of Turbines/Crane	50	50	50	50	50	50	50	50	50	50
Man Hours/Day	20	20	20	20	30	30	30	30	30	30
Estimated Crane Crew Man Hours/Turbine	23	23	41	41	61.5	123	172.5	172.5	310.5	310.5
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65	$65	$65	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$1,495	$1,495	$2,665	$2,665	$3,998	$7,995	$11,213	$11,213	$20,183	$20,183
3. Crane Relocation Information										
Estimated Relocation Hours/Turbine	6	6	6	8	8	14	21	25	25	33
Total Relocation Hours	300	300	300	400	400	700	1050	1250	1250	1650
Total Relocation Hours/Crane	300	300	300	400	400	700	1050	1250	1250	1650
Relocation Days/Crane	30	30	30	40	40	70	105	125	125	165
Estimated Relocation Days/Turbine	0.6	0.6	0.6	0.8	0.8	1.4	2.1	2.5	2.5	3.3
Crane Crew Relocation Man Hours/Turbine	12.0	12.0	12.0	16.0	24.0	42.0	63.0	75.0	75.0	99.0
Crane Crew Relocation Labor Costs/Turbine	$780	$780	$780	$1,040	$1,560	$2,730	$4,095	$4,875	$4,875	$6,435
Crane Costs During Relocation/Turbine	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
3. Totals										
Total Number of Crane Assembly Days/Turbine	1.75	1.75	2.65	2.85	2.85	5.50	7.85	8.25	12.85	13.65
Total Number of Days Required:	88	88	133	143	143	275	393	413	643	683
Total Number of Weeks Required	14.6	14.6	22.1	23.8	23.8	45.8	65.4	68.8	107.1	113.8
Installed kW per Day	429	429	566	0	526	455	446	424	272	366
Total Number of Months for Assembly	**3.4**	**3.4**	**5.1**	**5.5**	**5.5**	**10.6**	**15.1**	**15.9**	**24.7**	**26.3**
3 Month Min Crane Rental Costs	$45,000	$96,000	$112,500	$210,000	$270,000	$300,000	$375,000	$420,000	$420,000	$525,000
Total Crane Rental Charges	$50,481	$107,692	$191,106	$383,654	$493,269	$987,179	$1,698,317	$1,999,038	$2,998,333	$3,981,250
Crane Rental Costs/Turbine	$1,010	$2,154	$3,822	$7,673	$9,865	$19,744	$33,966	$39,981	$59,967	$79,625
4. Material/Supplies/Incidental Crane Costs										
Meals and Lodging/Person/Day	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75
Number of Person-Days	175	175	265	285	427.5	825	1177.5	1237.5	1927.5	2047.5
Total Meals and Lodging Costs	$13,125	$13,125	$19,875	$21,375	$32,063	$61,875	$88,313	$92,813	$144,563	$153,563
Meals and Lodging/Turbine	$263	$263	$398	$428	$641	$1,238	$1,766	$1,856	$2,891	$3,071
5. Fuel										
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	250	250	250	650	650	700	700	700	750
Total Cost of Fuel	$4,813	$5,469	$8,281	$8,906	$23,156	$44,688	$68,688	$72,188	$112,438	$127,969
Fuel Cost/Turbine	$96	$109	$166	$178	$463	$894	$1,374	$1,444	$2,249	$2,559
6. Cribbing										
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	3800	11900	11900	16150	10750	16150	18850	18850	18850
Cribbing Costs/Turbine	$131	$190	$595	$595	$808	$538	$808	$943	$943	$943
7. Mobilization and Demobilization										
Crane Assembly and Disassembly Hours	24	48	48	80	160	192	360	360	360	480
Lampson Supervisor Hours	24	48	48	80	160	192	360	360	360	480
Lampson Supervisor Hourly Cost	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4	6	6	8	8	8	10
Man Hours for Iron Workers	96	192	192	320	960	1152	2880	2880	2880	4800
Iron Worker Hourly Cost	$65	$65	$65	$65	$65	$65	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.3	0.3	0.5	0.9	1.1	2.0	2.0	2.0	2.7
Crane Rental Cost	$2,045	$8,727	$10,227	$31,818	$81,818	$109,091	$255,682	$286,364	$286,364	$477,273
Total Labor Costs	$8,040	$16,080	$16,080	$26,800	$74,400	$89,280	$214,200	$214,200	$214,200	$348,000
Truck Crane 1 Hourly Cost	$185	$185	$185	$185	$185	$185	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325	$325	$350	$350	$350	$350	$400
Truck Crane 3 Hourly Costs								$185	$185	$185
Total Truck Crane Costs	$12,240	$24,480	$24,480	$40,800	$81,600	$102,720	$192,600	$259,200	$259,200	$369,600
Total Transportation Freight in/out	$40,000	$60,000	$70,000	$80,000	$120,000	$120,000	$200,000	$220,000	$220,000	$220,000
Transport Days in/out	6	10	10	10	14	14	20	20	24	24
Transport Hours in/out	48	80	80	80	112	112	160	160	192	192
Crane Rental During Transport	$4,091	$14,545	$17,045	$31,818	$57,273	$63,636	$113,636	$127,273	$152,727	$190,909
SubTotal	$66,416	$123,833	$137,833	$211,236	$415,091	$484,727	$976,118	$1,107,036	$1,132,491	$1,605,782
Mob/Demob Costs/Turbine	$1,328	$2,477	$2,757	$4,225	$8,302	$9,695	$19,522	$22,141	$22,650	$32,116

Appendix J
Scenario 2—Bolting

Number of People in Crew:	10	100%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				62	$2,498		75	$3,023		96	$3,869		142	$5,723	
2. Fabricate Tower Assembly Area				14	$544	$1,289	14	$544	$1,289	14	$544	$1,289	14	$544	$1,289
3. Field Fabrication Tower Sections				101	$4,135	$6,621	333	$13,647	$20,701	588	$24,142	$34,315	952	$39,128	$51,509
4. Rig & Set Tower Sections				132	$5,320		243	$9,793		354	$14,265		619	$24,810	
5. Grout and Torque Bases				40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	61	$2,447	$250	95	$3,816	$500	112	$4,513	$700	164	$6,626	$1,000
7. Rig & Set Nacelle				57	$2,317		133	$6,488		174	$8,550		280	$13,370	
8. Install Safety Equipment				12	$484		20	$806		24	$968		36	$1,450	
9. General Conditions					$2,172	$5,713		$2,459	$10,789		$2,459	$10,789		$8,729	$20,941
10. Margin @ 10%					$2,153	$1,472		$4,295	$3,423		$6,213	$4,821		$10,389	$7,639
Subtotal Per Turbine				**479**	**$23,682**	**$16,195**	**972**	**$47,248**	**$37,652**	**1432**	**$68,345**	**$53,034**	**2294**	**$114,274**	**$84,028**
Percent of Total					59%	41%		56%	44%		56%	44%		58%	42%
Project Total (50 Turbines)				**23947.239**	**$1,184,123**	**$809,752**	**48596**	**$2,362,424**	**$1,882,619**	**71616**	**$3,417,233**	**$2,651,696**	**114721**	**$5,713,703**	**$4,201,393**
Total All Costs					**$1,993,875**			**$4,245,043**			**$6,068,929**			**$9,915,096**	
Total Cost per Turbine					**$39,878**			**$84,901**			**$121,379**			**$198,302**	
Estimated Assembly Rate - Items 2,5 (Hours)					**189**			**376**			**528**			**899**	
Estimated Assembly Rate - Items 2,5 (Days)					**1.9**			**3.8**			**5.3**			**9.0**	
Total Costs/kW					$26.49			$34.00			$35.12			$39.85	
Labor Costs/kW					$15.73			$18.92			$19.78			$22.96	
Equip.Mater Costs/kW					$10.76			$15.08			$15.35			$16.89	
Total Cost/Swept Area					$11.66			$14.96			$15.45			$17.53	
Man-Hours/Swept Area					0.14			0.17			0.18			0.20	
Labor Costs/Swept Area					$6.92			$8.33			$8.70			$10.10	
Equip, Mater Costs/Swept Area					$4.73			$6.64			$6.75			$7.43	
Total Costs/Hub Height					$465			$768			$934			$1,271	
Labor Costs/Hub Height					$276			$428			$526			$733	
Equip.Mater Costs/Hub Height					$189			$341			$408			$539	
Item 1 Hourly Rates				$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates				$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates				$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates				$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates				$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate				$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor				11%			6%			6%			5%		
Item 2 Percent of Labor				22%			21%			21%			22%		
Item 3 Percent of Labor				7%			5%			4%			3%		
Item 4 Percent of Labor				10%			8%			7%			6%		
Item 5 Percent of Labor				10%			14%			13%			12%		
Item 6 Percent of Labor				2%			2%			1%			1%		
Item 7 Percent of Labor				9%			5%			4%			8%		
Item 8 Percent of Labor				9%			9%			9%			9%		

Number of People in Crew:	10	75%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m)		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				40	$1,400		75	$2,625		96	$3,360		142	$4,970	
2. Fabricate Tower Assembly Area				12	$490	$1,160	12	$490	$1,160	12	$490	$1,160	12	$490	$1,160
3. Field Fabrication Tower Sections				91	$3,722	$5,959	300	$12,282	$18,631	530	$21,728	$30,883	857	$35,215	$46,358
4. Rig & Set Tower Sections				60	$2,100		110	$3,850		161	$5,635		282	$9,870	
5. Grout and Torque Bases				40	$1,400	$850	59	$2,065	$950	70	$2,450	$1,120	87	$3,045	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	57	$2,002	$250	87	$3,031	$500	101	$3,549	$700	147	$5,156	$1,000
7. Rig & Set Nacelle				22	$770		52	$2,537		68	$3,341		109	$5,205	
8. Install Safety Equipment				12	$420		20	$700		24	$840		36	$1,260	
9. General Conditions					$1,629	$4,285		$1,844	$8,092		$1,844	$8,092		$6,547	$15,706
10. Margin @ 10%					$1,393	$1,250		$2,942	$2,933		$4,324	$4,196		$7,176	$6,587
Subtotal Per Turbine				**335**	**$15,326**	**$13,754**	**715**	**$32,366**	**$32,266**	**1062**	**$47,561**	**$46,151**	**1673**	**$78,932**	**$72,461**
Percent of Total					53%	47%		50%	50%		51%	49%		52%	48%
Project Total (50 Turbines)				**16746.016**	**$766,296**	**$687,695**	**35755**	**$1,618,308**	**$1,613,323**	**53124**	**$2,378,047**	**$2,307,527**	**83636**	**$3,946,618**	**$3,623,065**
Total All Costs					**$1,453,991**			**$3,231,632**			**$4,685,574**			**$7,569,683**	
Total Cost per Turbine					**$29,080**			**$64,633**			**$93,711**			**$151,394**	
Estimated Assembly Rate - Items 2,5 (Hours)					**82**			**162**			**229**			**391**	
Estimated Assembly Rate - Items 2,5 (Days)					**0.8**			**1.6**			**2.3**			**3.9**	
Total Costs/kW					$19.32			$25.89			$27.12			$30.42	
Labor Costs/kW					$10.18			$12.96			$13.76			$15.86	
Equip.Mater Costs/kW					$9.14			$12.92			$13.35			$14.56	
Total Cost/Swept Area					$8.50			$11.39			$11.93			$13.39	
Man-Hours/Swept Area					0.10			0.13			0.14			0.15	
Labor Costs/Swept Area					$4.48			$5.70			$6.06			$6.98	
Equip, Mater Costs/Swept Area					$4.02			$5.69			$5.88			$6.41	
Total Costs/Hub Height					$339			$585			$721			$970	
Labor Costs/Hub Height					$179			$293			$366			$506	
Equip.Mater Costs/Hub Height					$160			$292			$355			$464	
Item 1 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 2 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 3 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 4 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 5 Hourly Rates				$35.00			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Combined Hourly Rate				$51.35											
Item 1 Percent of Labor				9%			8%			7%			6%		
Item 2 Percent of Labor				14%			12%			12%			13%		
Item 3 Percent of Labor				9%			6%			5%			4%		
Item 4 Percent of Labor				13%			9%			7%			7%		
Item 5 Percent of Labor				5%			8%			7%			7%		
Item 6 Percent of Labor				3%			2%			2%			2%		
Item 7 Percent of Labor				11%			6%			4%			8%		
Item 8 Percent of Labor				9%			9%			9%			9%		

Number of People in Crew:	10	105%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				64	$2,579		75	$3,023		96	$3,869		142	$5,723	
2. Fabricate Tower Assembly Area				16	$626	$1,483	16	$626	$1,483	16	$626	$1,483	16	$626	$1,483
3. Field Fabrication Tower Sections				117	$4,755	$7,614	383	$15,694	$23,807	677	$27,763	$39,462	1095	$44,997	$59,235
4. Rig & Set Tower Sections				138	$5,562		254	$10,236		371	$14,950		687	$27,535	
5. Grout and Torque Bases				40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	62	$2,487	$250	97	$3,905	$500	115	$4,633	$700	171	$6,900	$1,000
7. Rig & Set Nacelle				67	$2,724		155	$7,561		204	$10,024		348	$16,616	
8. Install Safety Equipment				12	$484		20	$806		24	$968		36	$1,450	
9. General Conditions					$2,281	$5,999		$2,582	$11,328		$2,582	$11,328		$9,165	$21,988
10. Margin @ 10%					$2,311	$1,619		$4,681	$3,807		$6,824	$5,409		$11,652	$8,536
Subtotal Per Turbine				**515**	**$25,420**	**$17,814**	**1059**	**$51,491**	**$41,874**	**1573**	**$75,061**	**$59,502**	**2582**	**$128,171**	**$93,891**
Percent of Total					59%	41%		55%	45%		56%	44%		58%	42%
Project Total (50 Turbines)				**25761.575**	**$1,271,009**	**$890,719**	**52960**	**$2,574,545**	**$2,093,710**	**78633**	**$3,753,057**	**$2,975,096**	**129106**	**$6,408,555**	**$4,694,564**
Total All Costs					**$2,161,728**			**$4,668,255**			**$6,728,153**			**$11,103,119**	
Total Cost per Turbine					**$43,235**			**$93,365**			**$134,563**			**$222,062**	
Estimated Assembly Rate - Items 2,5 (Hours)					**205**			**409**			**575**			**1,035**	
Estimated Assembly Rate - Items 2,5 (Days)					**2.1**			**4.1**			**5.8**			**10.4**	
Total Costs/kW					$28.72			$37.39			$38.94			$44.62	
Labor Costs/kW					$16.89			$20.62			$21.72			$25.76	
Equip.Mater Costs/kW					$11.83			$16.77			$17.22			$18.87	
Total Cost/Swept Area					$12.64			$16.45			$17.13			$19.63	
Man-Hours/Swept Area					0.15			0.19			0.20			0.23	
Labor Costs/Swept Area					$7.43			$9.07			$9.56			$11.33	
Equip, Mater Costs/Swept Area					$5.21			$7.38			$7.58			$8.30	
Total Costs/Hub Height					$504			$845			$1,035			$1,423	
Labor Costs/Hub Height					$296			$466			$577			$822	
Equip.Mater Costs/Hub Height					$208			$379			$458			$602	
Item 1 Hourly Rates				$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates				$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates				$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates				$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates				$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate				$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor				10%			6%			5%			4%		
Item 2 Percent of Labor				22%			20%			20%			21%		
Item 3 Percent of Labor				6%			5%			4%			3%		
Item 4 Percent of Labor				10%			8%			6%			5%		
Item 5 Percent of Labor				11%			15%			13%			13%		
Item 6 Percent of Labor				2%			2%			1%			1%		
Item 7 Percent of Labor				9%			5%			3%			7%		
Item 8 Percent of Labor				9%			9%			9%			9%		

BOLTED CONNECTIONS
1. Tower section properties based on data in Table 2-2.
2. See Page J-12 for determination of bolt count.
3. Overlap steel plate costs based on 18-inch wide by 1-inch thick sheet steel.

Tower Length	21.5	m
Volume of 1 plate	8.8	cu ft
Steel density	490	lb/cu ft
Steel cost	$0.35	/lb
Plate cost	$1,512	

Tower Section Assembly 1500 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0	$0	$160
Quarter-Section Bolts	119	BOLTS	10.5	11	$40	$453	$1.50	$179	$632
Half-Section Bolts	119	BOLTS	10.5	11	$40	$453	$1.50	$179	$632
Steel Overlap Plates	4	EA	0	0	$40	$0	$1,512	$6,049	$6,049
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0	$0	$320
Lifting Eyes	6	EA	1	6	$40	$240	$35	$210	$450
Paint	10	SF	5	2	$40	$80	$0.50	$5	$85
Non-Productive Time	3%	hours		3	$40	$102	$0	$0	$102
Torque Test Bolts	238	BOLTS	30	8	$50	$397		$0	$397
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
TOTALS (PER SECTION)				**101**		**$4,135**		**$6,621**	**$10,756**
Minimum	**-10%**			**91**		**$3,722**		**$5,959**	**$9,680**
Maximum	**15%**			**117**		**$4,755**		**$7,614**	**$12,369**

Total Number of Sections in Turbine:			1	101		**$4,135**		**$6,621**	**$10,756**
Minimum			1	91		**$3,722**		**$5,959**	**$9,680**
Maximum			1	117		**$4,755**		**$7,614**	**$12,369**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	1.0	0.9	1.2
Total number of sections for assembly	50	50	50
Number of days for assembly	51	46	58
Number of assembly days per turbine	1.0	0.9	1.2
Number of 6-day weeks	7.2	7.6	9.7

BOLTED CONNECTIONS

1. Tower section properties based on data in Table 2-2.
2. See Page J-12 for determination of bolt count.
3. Overlap steel plate costs based on 18-inch wide by 1-inch thick sheet steel.

Tower Length	22.1	m
Volume of 1 plate	9.1	cu ft
Steel density	490	lb/cu ft
Steel cost	$0.35	/lb
Plate cost	$1,554	

Tower Section Assembly 2500 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0	$0	$160
Quarter-Section Bolts	156	BOLTS	10.5	15	$40	$594	$1.50	$234	$828
Half-Section Bolts	156	BOLTS	10.5	15	$40	$594	$1.50	$234	$828
Steel Overlap Plates	4	EA	0	0	$40	$0	$1,554	$6,217	$6,217
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0	$0	$320
Lifting Eyes	6	EA	1	6	$40	$240	$35	$210	$450
Paint	10	SF	5	2	$40	$80	$0.50	$5	$85
Non-Productive Time	3%	hours		3	$40	$111	$0	$0	$111
Torque Test Bolts	312	BOLTS	30	10	$50	$520		$0	$520
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
TOTALS (PER SECTION)				**111**		**$4,549**		**$6,900**	**$11,449**
Minimum	**-10%**			**100**		**$4,094**		**$6,210**	**$10,304**
Maximum	**15%**			**128**		**$5,231**		**$7,936**	**$13,167**
Total Number of Sections in Turbine:			3	333		**$13,647**		**$20,701**	**$34,348**
Minimum			3	300		**$12,282**		**$18,631**	**$30,913**
Maximum			3	383		**$15,694**		**$23,807**	**$39,500**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	1.1	1.0	1.3
Total number of sections for assembly	150	150	150
Number of days for assembly	167	150	192
Number of assembly days per turbine	3.3	3.0	3.8
Number of 6-day weeks	23.8	25.0	31.9

BOLTED CONNECTIONS

1. Tower section properties based on data in Table 2-2.
2. See Page J-12 for determination of bolt count.
3. Overlap steel plate costs based on 18-inch wide by 1-inch thick sheet steel.

Tower Length	21.7	m
Volume of 1 plate	8.9	cu ft
Steel density	490	lb/cu ft
Steel cost	$0.35	/lb
Plate cost	$1,526	

Tower Section Assembly 3500 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0	$0	$160
Quarter-Section Bolts	181	BOLTS	10.5	17	$40	$690	$1.50	$272	$961
Half-Section Bolts	181	BOLTS	10.5	17	$40	$690	$1.50	$272	$961
Steel Overlap Plates	4	EA	0	0	$40	$0	$1,526	$6,105	$6,105
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0	$0	$320
Lifting Eyes	6	EA	1	6	$40	$240	$35	$210	$450
Paint	10	SF	5	2	$40	$80	$0.50	$5	$85
Non-Productive Time	3%	hours		3	$40	$117	$0	$0	$117
Torque Test Bolts	362	BOLTS	30	12	$50	$603		$0	$603
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
TOTALS (PER SECTION)				**118**		**$4,828**		**$6,863**	**$11,691**
Minimum	**-10%**			**106**		**$4,346**		**$6,177**	**$10,522**
Maximum	**15%**			**135**		**$5,553**		**$7,892**	**$13,445**
Total Number of Sections in Turbine:			5	588		**$24,142**		**$34,315**	**$58,456**
Minimum			5	530		**$21,728**		**$30,883**	**$52,611**
Maximum			5	677		**$27,763**		**$39,462**	**$67,225**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	1.2	1.1	1.4
Total number of sections for assembly	250	250	250
Number of days for assembly	294	265	338
Number of assembly days per turbine	5.9	5.3	6.8
Number of 6-day weeks	49.0	44.1	56.4

BOLTED CONNECTIONS
1. Tower section properties based on data in Table 2-2.
2. See Page J-12 for determination of bolt count.
3. Overlap steel plate costs based on 18-inch wide by 1-inch thick sheet steel.

Tower Length	22.3	m
Volume of 1 plate	9.1	cu ft
Steel density	490	lb/cu ft
Steel cost	$0.35	/lb
Plate cost	$1,568	

Tower Section Assembly 5000 kW

Descriptior	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0	$0	$160
Quarter-Section Bolts	223	BOLTS	9	25	$40	$991	$1.95	$435	$1,426
Half-Section Bolts	223	BOLTS	9	25	$40	$991	$1.95	$435	$1,426
Steel Overlap Plates	4	EA	0	0	$40	$0	$1,568	$6,274	$6,274
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0	$0	$320
Lifting Eyes	6	EA	1	6	$40	$240	$35	$210	$450
Paint	10	SF	5	2	$40	$80	$0.50	$5	$85
Non-Productive Time	3%	hours		3	$40	$135	$0	$0	$135
Torque Test Bolts	446	BOLTS	30	15	$50	$743		$0	$743
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
TOTALS (PER SECTION)				**136**		**$5,590**		**$7,358**	**$12,948**
Minimum	**-10%**			**122**		**$5,031**		**$6,623**	**$11,653**
Maximum	**15%**			**156**		**$6,428**		**$8,462**	**$14,890**
Total Number of Sections in Turbine:			7	952		**$39,128**		**$51,509**	**$90,636**
Minimum			7	857		**$35,215**		**$46,358**	**$81,573**
Maximum			7	1095		**$44,997**		**$59,235**	**$104,232**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	1.4	1.2	1.6
Total number of sections for assembly	350	350	350
Number of days for assembly	476	428	547
Number of assembly days per turbine	9.5	8.6	10.9
Number of 6-day weeks	79.3	71.4	91.2

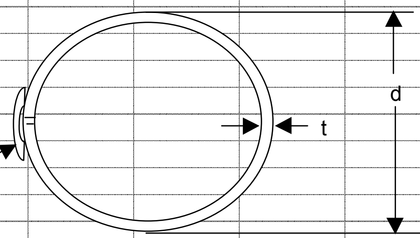
Turbine Class:	1,500			2,500			3,500			5000		
Rotor Diameter:	66			85			100			120		
Crane Type:	4100 S1			4100 S1			4600 S4			4600 S5		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Crane Crew Assembly Labor Costs/Turbine	$1,186	$1,318	$1,516	$3,900	$4,334	$4,984	$6,885	$7,650	$8,798	$11,140	$12,378	$14,235
Crane Crew Relocation Labor Costs/Turbine	0	0	0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Crane Rental Costs During Assembly and Relocation/Turbine	$900	$900	$900	$1,731	$1,923	$2,212	$6,518	$7,243	$8,329	$12,360	$13,733	$15,793
Meals and Lodging/Turbine	$137	$152	$175	$450	$500	$575	$794	$883	$1,015	$1,285	$1,428	$1,642
Fuel Cost/Turbine	$50	$56	$64	$165	$183	$211	$331	$368	$423	$536	$595	$684
Cribbing Costs/Turbine	$131	$131	$131	$131	$131	$131	$190	$190	$190	$595	$595	$595
Mob/Demob Costs/Turbine	$1,328	$1,328	$1,328	$1,328	$1,328	$1,328	$2,477	$2,477	$2,477	$2,757	$2,757	$2,757
Total Crane and Crew Costs/Turbine	**$3,732**	**$3,885**	**$4,114**	**$7,705**	**$8,399**	**$9,441**	**$17,196**	**$18,810**	**$21,231**	**$28,673**	**$31,487**	**$35,707**
Total Crane Costs (50 Turbines)	**$186,624**	**$194,254**	**$205,699**	**$385,272**	**$419,974**	**$472,027**	**$859,776**	**$940,492**	**$1,061,566**	**$1,433,654**	**$1,574,328**	**$1,785,340**
Costs/kW	$2.48	$2.58	$2.73	$3.09	$3.36	$3.78	$4.98	$5.44	$6.14	$5.76	$6.33	$7.18
Costs/Swept Area	$1.09	$1.14	$1.20	$1.36	$1.48	$1.66	$2.19	$2.39	$2.70	$2.54	$2.78	$3.16

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Tower Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	1.0	3.3	5.9	9.5
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	20	67	118	190
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$1,318	$4,334	$7,650	$12,378
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	1.0	3.3	5.9	9.5
Total Number of Days Required:	51	167	294	476
Total Number of Weeks Required	8.4	27.8	49.0	79.3
Total Number of Months for Assembly	**1.9**	**6.4**	**11.3**	**18.3**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$29,249	$96,163	$362,133	$686,664
Crane Rental Costs/Turbine	$900	$1,923	$7,243	$13,733
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	101.3959556	333.3650095	588.4654921	952.1739111
Total Meals and Lodging Costs	$7,605	$25,002	$44,135	$71,413
Meals and Lodging/Turbine	$152	$500	$883	$1,428
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$2,788	$9,168	$18,390	$29,755
Fuel Cost/Turbine	$56	$183	$368	$595
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	0.9	3.0	5.3	8.6
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	18	60	106	171
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$1,186	$3,900	$6,885	$11,140
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	0.9	3.0	5.3	8.6
Total Number of Days Required:	46	150	265	428
Total Number of Weeks Required	7.6	25.0	44.1	71.4
Total Number of Months for Assembly	**1.8**	**5.8**	**10.2**	**16.5**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$26,324	$86,547	$325,919	$617,997
Crane Rental Costs/Turbine	$900	$1,731	$6,518	$12,360
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	91.25636	300.0285086	529.6189429	856.95652
Total Meals and Lodging Costs	$6,844	$22,502	$39,721	$64,272
Meals and Lodging/Turbine	$137	$450	$794	$1,285
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$2,510	$8,251	$16,551	$26,780
Fuel Cost/Turbine	$50	$165	$331	$536
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	1.2	3.8	6.8	10.9
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	23	77	135	219
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$1,516	$4,984	$8,798	$14,235
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	1.2	3.8	6.8	10.9
Total Number of Days Required:	58	192	338	547
Total Number of Weeks Required	9.7	31.9	56.4	91.2
Total Number of Months for Assembly	**2.2**	**7.4**	**13.0**	**21.1**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$33,636	$110,587	$416,453	$789,663
Crane Rental Costs/Turbine	$900	$2,212	$8,329	$15,793
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	116.6053489	383.369761	676.7353159	1094.999998
Total Meals and Lodging Costs	$8,745	$28,753	$50,755	$82,125
Meals and Lodging/Turbine	$175	$575	$1,015	$1,642
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$3,207	$10,543	$21,148	$34,219
Fuel Cost/Turbine	$64	$211	$423	$684
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Calculation of shear flow in longitudinal tower connections
Assume calculation at base of tower for maximum shear



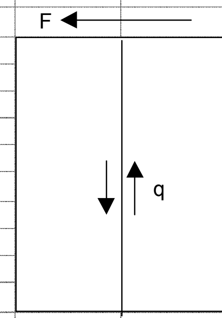
Shear Flow

$$q = \frac{F \times Q}{I}$$

Where:

$$I = 1/8 \times Pi \times d^3 \times t$$

and Q is the statical moment of the tower thickness about the neutral axis



Calculate Q for half a tower section by integrating over Pi radians (180 degrees)

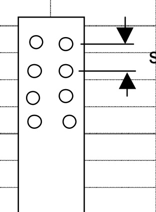
$$Q = (t \times d^2)/2$$

Therefore, the shear flow is:

$$q = \frac{F \times (t \times d^2)/2}{(Pi \times d^3 \times t)/8}$$

---- OR ----

$$q = \frac{4 \times F}{Pi \times d} \text{ (in kN/m)}$$



To determine bolt spacing, obtain the design shear capacity of one bolt:
- For a M24, A325 bolt, the single shear is 168 kN/bolt

$$v_r = 168$$

Then:

$$s \times q = v_r$$

---- OR ----

$$s = \frac{v_r \times Pi \times d}{4 \times F}$$

Rotor Thrust = ((0.5 x air density x wind speed^2 x flapwise Cd x solidity x Pi x D^2/4)/1000 N) load factor

Using wind speed, air density, Cd, solidity, and load factor from GEC Tower Design spreadsheet

density =	1.225	
wind speed =	59.5	m/s
Cd =	1.8	
solidity	0.05	
load factor =	1.35	

D (m) =	50	66	85	100	120	
d (m) =	3.7	4.9	6.4	7.5	9	(Base Diameters from GEC Tower Design)
F (kN) =	517	901	1495	2069	2980	
s (m/bolt) =	0.9	0.7	0.6	0.5	0.4	
s (ft/bolt) =	3.1	2.4	1.9	1.6	1.3	
Tower Sections (m) =	21.7	21.5	22.1	21.7	22.3	
Bolts per Joint =	46	60	78	91	112	(Total number of bolts on one overlap plate)

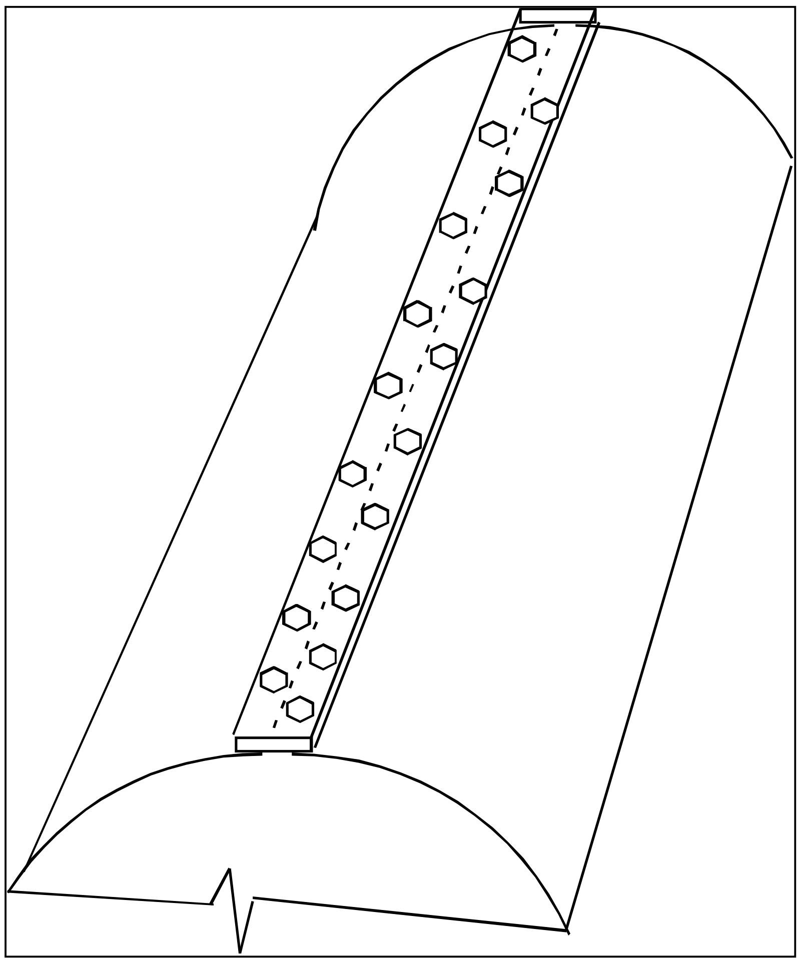


Illustration of bolted tower overlap joint. Overlap joint runs the entire length of the tower section. This view shows the connection between 2 quartered tower sections.

Appendix K
Scenario 2—Welding

Number of People in Crew:	10	100%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				62	$2,498		75	$3,023		96	$3,869		142	$5,723	
2. Fabricate Tower Assembly Area				14	$544	$1,289	14	$544	$1,289	14	$544	$1,289	14	$544	$1,289
3. Field Fabrication Tower Sections				317	$13,193	$8,625	966	$40,134	$26,339	2456	$100,739	$62,121	5479	$222,673	$128,899
4. Rig & Set Tower Sections				132	$5,320		243	$9,793		354	$14,265		619	$24,810	
5. Grout and Torque Bases				40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	61	$2,447	$250	95	$3,816	$500	112	$4,513	$700	164	$6,626	$1,000
7. Rig & Set Nacelle				57	$2,317		133	$6,488		174	$8,550		280	$13,370	
8. Install Safety Equipment				12	$484		20	$806		24	$968		36	$1,450	
9. General Conditions					$2,172	$5,713		$2,459	$10,789		$2,459	$10,789		$8,729	$20,941
10. Margin @ 10%					$3,059	$1,673		$6,944	$3,987		$13,873	$7,602		$28,743	$15,378
Subtotal Per Turbine				**695**	**$33,646**	**$18,400**	**1604**	**$76,385**	**$43,854**	**3300**	**$152,601**	**$83,621**	**6822**	**$316,174**	**$169,158**
Percent of Total					65%	35%		64%	36%		65%	35%		65%	35%
Project Total (50 Turbines)				**34744**	**$1,682,312**	**$919,997**	**80220**	**$3,819,231**	**$2,192,689**	**164991**	**$7,630,070**	**$4,181,072**	**341079**	**$15,808,693**	**$8,457,879**
Total All Costs					**$2,602,309**			**$6,011,920**			**$11,811,142**			**$24,266,571**	
Total Cost per Turbine					**$52,046**			**$120,238**			**$236,223**			**$485,331**	
Estimated Assembly Rate - Items 2,5 (Hours)					**189**			**376**			**528**			**899**	
Estimated Assembly Rate - Items 2,5 (Days)					**1.9**			**3.8**			**5.3**			**9.0**	
Total Costs/kW					$34.57			$48.16			$68.36			$97.53	
Labor Costs/kW					$22.35			$30.59			$44.16			$63.54	
Equip.Mater Costs/kW					$12.22			$17.56			$24.20			$33.99	
Total Cost/Swept Area					$15.21			$21.19			$30.08			$42.91	
Man-Hours/Swept Area					0.20			0.28			0.42			0.60	
Labor Costs/Swept Area					$9.83			$13.46			$19.43			$27.96	
Equip, Mater Costs/Swept Area					$5.38			$7.73			$10.65			$14.96	
Total Costs/Hub Height					$607			$1,088			$1,817			$3,111	
Labor Costs/Hub Height					$392			$691			$1,174			$2,027	
Equip.Mater Costs/Hub Height					$214			$397			$643			$1,084	
Item 1 Hourly Rates				$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates				$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates				$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates				$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates				$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate				$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor				7%			4%			3%			2%		
Item 2 Percent of Labor				16%			13%			9%			8%		
Item 3 Percent of Labor				5%			3%			2%			1%		
Item 4 Percent of Labor				7%			5%			3%			2%		
Item 5 Percent of Labor				7%			8%			6%			4%		
Item 6 Percent of Labor				1%			1%			1%			0%		
Item 7 Percent of Labor				6%			3%			2%			3%		
Item 8 Percent of Labor				9%			9%			9%			9%		

Number of People in Crew:	10	75%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				40	$1,400		75	$2,625		96	$3,360		142	$4,970	
2. Fabricate Tower Assembly Area				12	$490	$1,160	12	$490	$1,160	12	$490	$1,160	12	$490	$1,160
3. Field Fabrication Tower Sections				286	$11,874	$7,763	869	$36,121	$23,705	2210	$90,665	$55,909	4931	$200,406	$116,010
4. Rig & Set Tower Sections				60	$2,100		110	$3,850		161	$5,635		282	$9,870	
5. Grout and Torque Bases				40	$1,400	$850	59	$2,065	$950	70	$2,450	$1,120	87	$3,045	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	57	$2,002	$250	87	$3,031	$500	101	$3,549	$700	147	$5,156	$1,000
7. Rig & Set Nacelle				22	$770		52	$2,537		68	$3,341		109	$5,205	
8. Install Safety Equipment				12	$420		20	$700		24	$840		36	$1,260	
9. General Conditions					$1,629	$4,285		$1,844	$8,092		$1,844	$8,092		$6,547	$15,706
10. Margin @ 10%					$2,208	$1,431		$5,326	$3,441		$11,217	$6,698		$23,695	$13,553
Subtotal Per Turbine				**529**	**$24,293**	**$15,738**	**1284**	**$58,589**	**$37,848**	**2743**	**$123,392**	**$73,679**	**5747**	**$260,642**	**$149,078**
Percent of Total					61%	39%		61%	39%		63%	37%		64%	36%
Project Total (50 Turbines)				**26463**	**$1,214,666**	**$786,915**	**64216**	**$2,929,435**	**$1,892,386**	**137162**	**$6,169,600**	**$3,683,965**	**287358**	**$13,032,108**	**$7,453,902**
Total All Costs					**$2,001,581**			**$4,821,821**			**$9,853,565**			**$20,486,010**	
Total Cost per Turbine					**$40,032**			**$96,436**			**$197,071**			**$409,720**	
Estimated Assembly Rate - Items 2,5 (Hours)					**82**			**162**			**229**			**391**	
Estimated Assembly Rate - Items 2,5 (Days)					**0.8**			**1.6**			**2.3**			**3.9**	
Total Costs/kW					$26.59			$38.62			$57.03			$82.33	
Labor Costs/kW					$16.14			$23.47			$35.71			$52.38	
Equip.Mater Costs/kW					$10.46			$15.16			$21.32			$29.96	
Total Cost/Swept Area					$11.70			$16.99			$25.09			$36.23	
Man-Hours/Swept Area					0.15			0.23			0.35			0.51	
Labor Costs/Swept Area					$7.10			$10.32			$15.71			$23.05	
Equip, Mater Costs/Swept Area					$4.60			$6.67			$9.38			$13.18	
Total Costs/Hub Height					$467			$873			$1,516			$2,626	
Labor Costs/Hub Height					$283			$530			$949			$1,671	
Equip.Mater Costs/Hub Height					$183			$343			$567			$956	
Item 1 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 2 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 3 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 4 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 5 Hourly Rates				$35.00			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Combined Hourly Rate															
Item 1 Percent of Labor				6%			4%			3%			2%		
Item 2 Percent of Labor				9%			7%			5%			4%		
Item 3 Percent of Labor				6%			4%			2%			1%		
Item 4 Percent of Labor				8%			5%			3%			2%		
Item 5 Percent of Labor				3%			4%			3%			2%		
Item 6 Percent of Labor				2%			1%			1%			0%		
Item 7 Percent of Labor				7%			3%			1%			3%		
Item 8 Percent of Labor				9%			9%			9%			9%		

Number of People in Crew:	10	105%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				64	$2,579		75	$3,023		96	$3,869		142	$5,723	
2. Fabricate Tower Assembly Area				16	$626	$1,483	16	$626	$1,483	16	$626	$1,483	16	$626	$1,483
3. Field Fabrication Tower Sections				365	$15,172	$9,919	1111	$46,154	$30,290	2824	$115,850	$71,440	6301	$256,074	$148,234
4. Rig & Set Tower Sections				138	$5,562		254	$10,236		371	$14,950		687	$27,535	
5. Grout and Torque Bases				40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	62	$2,487	$250	97	$3,905	$500	115	$4,633	$700	171	$6,900	$1,000
7. Rig & Set Nacelle				67	$2,724		155	$7,561		204	$10,024		348	$16,616	
8. Install Safety Equipment				12	$484		20	$806		24	$968		36	$1,450	
9. General Conditions					$2,281	$5,999		$2,582	$11,328		$2,582	$11,328		$9,165	$21,988
10. Margin @ 10%					$3,353	$1,850		$7,727	$4,455		$15,632	$8,607		$32,760	$17,435
Subtotal Per Turbine				**764**	**$36,879**	**$20,350**	**1787**	**$84,997**	**$49,006**	**3720**	**$171,956**	**$94,678**	**7788**	**$360,356**	**$191,790**
Percent of Total					64%	36%		63%	37%		64%	36%		65%	35%
Project Total (50 Turbines)				**38,178**	**$1,843,927**	**$1,017,500**	**89,328**	**$4,249,873**	**$2,450,291**	**186,015**	**$8,597,819**	**$4,733,878**	**389,417**	**$18,017,793**	**$9,589,522**
Total All Costs					**$2,861,427**			**$6,700,164**			**$13,331,697**			**$27,607,315**	
Total Cost per Turbine					**$57,229**			**$134,003**			**$266,634**			**$552,146**	
Estimated Assembly Rate - Items 2,5 (Hours)					**205**			**409**			**575**			**1,035**	
Estimated Assembly Rate - Items 2,5 (Days)					**2.1**			**4.1**			**5.8**			**10.4**	
Total Costs/kW					$38.02			$53.67			$77.16			$110.96	
Labor Costs/kW					$24.50			$34.04			$49.76			$72.41	
Equip.Mater Costs/kW					$13.52			$19.63			$27.40			$38.54	
Total Cost/Swept Area					$16.73			$23.61			$33.95			$48.82	
Man-Hours/Swept Area					0.22			0.31			0.47			0.69	
Labor Costs/Swept Area					$10.78			$14.98			$21.89			$31.86	
Equip, Mater Costs/Swept Area					$5.95			$8.64			$12.05			$16.96	
Total Costs/Hub Height					$667			$1,213			$2,051			$3,539	
Labor Costs/Hub Height					$430			$769			$1,323			$2,310	
Equip.Mater Costs/Hub Height					$237			$443			$728			$1,229	
Item 1 Hourly Rates				$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates				$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates				$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates				$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates				$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate				$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor				7%			4%			2%			2%		
Item 2 Percent of Labor				15%			12%			9%			8%		
Item 3 Percent of Labor				4%			3%			2%			1%		
Item 4 Percent of Labor				7%			5%			3%			2%		
Item 5 Percent of Labor				7%			9%			6%			5%		
Item 6 Percent of Labor				1%			1%			1%			0%		
Item 7 Percent of Labor				6%			3%			2%			3%		
Item 8 Percent of Labor				9%			9%			9%			9%		

WELDED QUARTER SECTIONS OF TOWERS

1. Tower section properties based on data in Table 2-2.
2. See Page N-3 for weight of weld.
3. Assumed manual weld rate: 4 lbs/hr

Weld weight - 1 inch steel	2.25	lb/ft
Welding rate	21.3	in/hr
Tower section length	21.5	m
Tower section length	846	in

Tower Section Assembly 1500 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0.00	$0	$160
Quarter-Section Weld	1693	INCHES	21.3	79	$40	$3,174	$0.58	$982	$4,156
Half-Section Weld	1693	INCHES	21.3	79	$40	$3,174	$0.58	$982	$4,156
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0.00	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0.00	$0	$320
Lifting Eyes	5.33	EA	1	5.33	$40	$213	$35.00	$187	$400
Paint	5000	SF	80	63	$40	$2,500	$0.50	$2,500	$5,000
Non-Productive Time	3%	MHRS		8	$40	$337	$0.00	$0	$337
X-RAY TEST	20	EA	1	20	$65	$1,300	$20.00	$400	$1,700
Weld Correction (1%)	34	INCHES	16	2	$40	$85	$0.58	$20	$104
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
Welding Equipment/Operating Costs	282	LF				$0	$12.60	$3,555	$3,555
TOTALS (PER SECTION)				**317**		**$13,193**		**$8,625**	**$21,818**
Minimum	**-10%**			**286**		**$11,874**		**$7,763**	**$19,636**
Maximum	**15%**			**365**		**$15,172**		**$9,919**	**$25,091**
Total Number of Sections in Turbine:			1	317		**$13,193**		**$8,625**	**$21,818**
Minimum			1	286		**$11,874**		**$7,763**	**$19,636**
Maximum			1	365		**$15,172**		**$9,919**	**$25,091**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	3.2	2.9	3.6
Total number of sections for assembly	50	50	50
Number of days for assembly	159	143	182
Number of assembly days per turbine	3.2	2.9	3.6
Number of 6 day weeks	26.4	23.8	30.4

WELDED QUARTER SECTIONS OF TOWERS

1. Tower section properties based on data in Table 2-2.
2. See Page N-3 for weight of weld.
3. Assumed manual weld rate: 4 lbs/hr

Weld weight - 1 inch steel	2.25	lb/ft
Welding rate	21.3	in/hr
Tower section length	22.1	m
Tower section length	870	in

Tower Section Assembly 2500 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0.00	$0	$160
Quarter-Section Weld	1740	INCHES	21.3	82	$40	$3,263	$0.58	$1,009	$4,272
Half-Section Weld	1740	INCHES	21.3	82	$40	$3,263	$0.58	$1,009	$4,272
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0.00	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0.00	$0	$320
Lifting Eyes	5.33	EA	1	5.33	$40	$213	$35.00	$187	$400
Paint	5000	SF	80	63	$40	$2,500	$0.50	$2,500	$5,000
Non-Productive Time	3%	MHRS		9	$40	$343	$0.00	$0	$343
X-RAY TEST	20	EA	1	20	$65	$1,300	$20.00	$400	$1,700
Weld Correction (1%)	35	INCHES	16	2	$40	$87	$0.58	$20	$107
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
Welding Equipment/Operating Costs	290	LF				$0	$12.60	$3,654	$3,654
TOTALS (PER SECTION)				**322**		**$13,378**		**$8,780**	**$22,158**
Minimum	**-10%**			**290**		**$12,040**		**$7,902**	**$19,942**
Maximum	**15%**			**370**		**$15,385**		**$10,097**	**$25,481**
Total Number of Sections in Turbine:			3	966		**$40,134**		**$26,339**	**$66,473**
Minimum			3	869		**$36,121**		**$23,705**	**$59,826**
Maximum			3	1111		**$46,154**		**$30,290**	**$76,444**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	3.2	2.9	3.7
Total number of sections for assembly	150	150	150
Number of days for assembly	483	435	555
Number of assembly days per turbine	9.7	8.7	11.1
Number of 6-day weeks	80.5	72.4	92.6

WELDED QUARTER SECTIONS OF TOWERS

1. Tower section properties based on data in Table 2-2.
2. See Page N-3 for weight of weld.
3. Assumed manual weld rate: 4 lbs/hr

Weld weight - 1.5 inch steel	4.6	lb/ft
Welding rate	10.4	in/hr
Tower section length	21.7	m
Tower section length	854	in

Tower Section Assembly 3500 MW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0.00	$0	$160
Quarter-Section Weld	1709	INCHES	10.4	164	$40	$6,550	$0.58	$991	$7,541
Half-Section Weld	1709	INCHES	10.4	164	$40	$6,550	$0.58	$991	$7,541
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0.00	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0.00	$0	$320
Lifting Eyes	5.33	EA	1	5.33	$40	$213	$35.00	$187	$400
Paint	5000	SF	80	63	$40	$2,500	$0.50	$2,500	$5,000
Non-Productive Time	3%	MHRS		14	$40	$540	$0.00	$0	$540
X-RAY TEST	20	EA	1	20	$65	$1,300	$20.00	$400	$1,700
Weld Correction (1%)	34	INCHES	16	2	$40	$85	$0.58	$20	$105
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
Welding Equipment/Operating Costs	285	LF				$0	$25.76	$7,336	$7,336
TOTALS (PER SECTION)				**491**		**$20,148**		**$12,424**	**$32,572**
Minimum	**-10%**			**442**		**$18,133**		**$11,182**	**$29,315**
Maximum	**15%**			**565**		**$23,170**		**$14,288**	**$37,458**
Total Number of Sections in Turbine:			5	2456		**$100,739**		**$62,121**	**$162,860**
Minimum			5	2210		**$90,665**		**$55,909**	**$146,574**
Maximum			5	2824		**$115,850**		**$71,440**	**$187,289**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	4.9	4.4	5.6
Total number of sections for assembly	250	250	250
Number of days for assembly	1228	1105	1412
Number of assembly days per turbine	24.6	22.1	28.2
Number of 6-day weeks	204.7	184.2	235.4

WELDED QUARTER SECTIONS OF TOWERS

1. Tower section properties based on data in Table 2-2.
2. See Page N-3 for weight of weld.
3. Assumed manual weld rate: 4 lbs/hr

Weld weight - 2 inch steel	7.8	lb/ft
Welding rate	6.2	in/hr
Tower section length	22.3	m
Tower section length	878	in

Tower Section Assembly 5000 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	24	EA	4	6	$40	$240	$0.00	$0	$240
Quarter-Section Weld	1756	INCHES	6.2	285	$40	$11,413	$0.58	$1,018	$12,432
Half-Section Weld	1756	INCHES	6.2	285	$40	$11,413	$0.58	$1,018	$12,432
Top & Bottom Template	16	EA	0.25	64	$40	$2,560	$0.00	$0	$2,560
Move Cradles	24	EA	2	12	$40	$480	$0.00	$0	$480
Lifting Eyes	8	EA	1	8	$40	$320	$35.00	$280	$600
Paint	5788	SF	80	72	$40	$2,894	$0.50	$2,894	$5,788
Non-Productive Time	3%	MHRS		22	$40	$880	$0.00	$0	$880
X-RAY TEST	20	EA	1	20	$65	$1,300	$20.00	$400	$1,700
Weld Correction (1%)	35	INCHES	16	2	$40	$88	$0.58	$20	$108
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
Welding Equipment/Operating Costs	293	LF				$0	$43.68	$12,783	$12,783
TOTALS (PER SECTION)				**783**		**$31,810**		**$18,414**	**$50,225**
Minimum	**-10%**			**704**		**$28,629**		**$16,573**	**$45,202**
Maximum	**15%**			**900**		**$36,582**		**$21,176**	**$57,758**
Total Number of Sections in Turbine:			7	5479		**$222,673**		**$128,899**	**$351,572**
Minimum			7	4931		**$200,406**		**$116,010**	**$316,415**
Maximum			7	6301		**$256,074**		**$148,234**	**$404,308**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	7.8	7.0	9.0
Total number of sections for assembly	350	350	350
Number of days for assembly	2740	2466	3151
Number of assembly days per turbine	54.8	49.3	63.0
Number of 6-day weeks	456.6	410.9	525.1

Turbine Class:	1,500			2,500			3,500			5000		
Rotor Diameter:	66			85			100			120		
Crane Type:	4100 S1			4100 S1			4600 S4			4600 S5		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Crane Crew Assembly Labor Costs/Turbine	$3,713	$4,125	$4,744	$11,300	$12,556	$14,439	$28,735	$31,928	$36,717	$64,108	$71,231	$81,916
Crane Crew Relocation Labor Costs/Turbine	0	0	0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Crane Rental Costs During Assembly and Relocation/Turbine	$1,648	$1,831	$2,105	$5,015	$5,572	$6,408	$27,205	$30,227	$34,761	$71,126	$79,029	$90,883
Meals and Lodging/Turbine	$428	$476	$547	$1,304	$1,449	$1,666	$3,316	$3,684	$4,237	$7,397	$8,219	$9,452
Fuel Cost/Turbine	$157	$175	$201	$478	$531	$611	$1,381	$1,535	$1,765	$3,082	$3,425	$3,938
Cribbing Costs/Turbine	$131	$131	$131	$131	$131	$131	$190	$190	$190	$595	$595	$595
Mob/Demob Costs/Turbine	$1,328	$1,328	$1,328	$1,328	$1,328	$1,328	$2,477	$2,477	$2,477	$2,757	$2,757	$2,757
Total Crane and Crew Costs/Turbine	**$7,405**	**$8,066**	**$9,057**	**$19,557**	**$21,567**	**$24,584**	**$63,303**	**$70,041**	**$80,147**	**$149,065**	**$165,255**	**$189,541**
Total Crane Costs (50 Turbines)	**$370,248**	**$403,281**	**$452,830**	**$977,825**	**$1,078,367**	**$1,229,179**	**$3,165,163**	**$3,502,033**	**$4,007,337**	**$7,453,237**	**$8,262,754**	**$9,477,030**
Costs/kW	$4.92	$5.36	$6.02	$7.83	$8.64	$9.85	$18.32	$20.27	$23.19	$29.96	$33.21	$38.09
Costs/Swept Area	$2.16	$2.36	$2.65	$3.45	$3.80	$4.33	$8.06	$8.92	$10.20	$13.18	$14.61	$16.76

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Tower Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	3	10	25	55
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	63	193	491	1096
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$4,125	$12,556	$31,928	$71,231
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	3.2	9.7	24.6	54.8
Total Number of Days Required:	159	483	1228	2740
Total Number of Weeks Required	26.4	80.5	204.7	456.6
Total Number of Months for Assembly	**6.1**	**18.6**	**47.2**	**105.4**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$91,537	$278,611	$1,511,369	$3,951,434
Crane Rental Costs/Turbine	$1,831	$5,572	$30,227	$79,029
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	317.3289461	965.8500273	2455.974619	5479.322153
Total Meals and Lodging Costs	$23,800	$72,439	$184,198	$410,949
Meals and Lodging/Turbine	$476	$1,449	$3,684	$8,219
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$8,727	$26,561	$76,749	$171,229
Fuel Cost/Turbine	$175	$531	$1,535	$3,425
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	2.9	8.7	22.1	49.3
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	57	174	442	986
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$3,713	$11,300	$28,735	$64,108
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	2.9	8.7	22.1	49.3
Total Number of Days Required:	143	435	1105	2466
Total Number of Weeks Required	23.8	72.4	184.2	410.9
Total Number of Months for Assembly	**5.5**	**16.7**	**42.5**	**94.8**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$82,383	$250,750	$1,360,232	$3,556,291
Crane Rental Costs/Turbine	$1,648	$5,015	$27,205	$71,126
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	285.5960515	869.2650246	2210.377157	4931.389937
Total Meals and Lodging Costs	$21,420	$65,195	$165,778	$369,854
Meals and Lodging/Turbine	$428	$1,304	$3,316	$7,397
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$7,854	$23,905	$69,074	$154,106
Fuel Cost/Turbine	$157	$478	$1,381	$3,082
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	3.6	11.1	28.2	63.0
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	73	222	565	1260
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$4,744	$14,439	$36,717	$81,916
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	3.6	11.1	28.2	63.0
Total Number of Days Required:	182	555	1412	3151
Total Number of Weeks Required	30.4	92.6	235.4	525.1
Total Number of Months for Assembly	**7.0**	**21.4**	**54.3**	**121.2**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$105,268	$320,402	$1,738,074	$4,544,149
Crane Rental Costs/Turbine	$2,105	$6,408	$34,761	$90,883
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	364.928288	1110.727531	2824.370812	6301.220476
Total Meals and Lodging Costs	$27,370	$83,305	$211,828	$472,592
Meals and Lodging/Turbine	$547	$1,666	$4,237	$9,452
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$10,036	$30,545	$88,262	$196,913
Fuel Cost/Turbine	$201	$611	$1,765	$3,938
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Appendix L
Scenario 2—Automated Welding

Number of People in Crew:	10	100%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				62	$2,498		75	$3,023		96	$3,869		142	$5,723	
2. Fabricate Tower Assembly Area				14	$544	$1,289	14	$544	$1,289	14	$544	$1,289	14	$544	$1,289
3. Field Fabrication Tower Sections				236	$9,924	$6,848	714	$30,052	$20,857	1613	$67,007	$43,782	3422	$140,382	$84,159
4. Rig & Set Tower Sections				132	$5,320		243	$9,793		354	$14,265		619	$24,810	
5. Grout and Torque Bases				40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	61	$2,447	$250	95	$3,816	$500	112	$4,513	$700	164	$6,626	$1,000
7. Rig & Set Nacelle				57	$2,317		133	$6,488		174	$8,550		280	$13,370	
8. Install Safety Equipment				12	$484		20	$806		24	$968		36	$1,450	
9. General Conditions					$2,172	$5,713		$2,459	$10,789		$2,459	$10,789		$8,729	$20,941
10. Margin @ 10%					$2,732	$1,495		$5,936	$3,439		$10,500	$5,768		$20,514	$10,904
Subtotal Per Turbine				**613**	**$30,050**	**$16,445**	**1352**	**$65,294**	**$37,824**	**2457**	**$115,496**	**$63,448**	**4764**	**$225,654**	**$119,943**
Percent of Total					65%	35%		63%	37%		65%	35%		65%	35%
Project Total (50 Turbines)				**30657.09**	**$1,502,493**	**$822,231**	**67617**	**$3,264,719**	**$1,891,207**	**122826**	**$5,774,820**	**$3,172,392**	**238215**	**$11,282,715**	**$5,997,153**
Total All Costs					**$2,324,724**			**$5,155,926**			**$8,947,211**			**$17,279,867**	
Total Cost per Turbine					**$46,494**			**$103,119**			**$178,944**			**$345,597**	
Estimated Assembly Rate - Items 2,5 (Hours)					**189**			**376**			**528**			**899**	
Estimated Assembly Rate - Items 2,5 (Days)					**1.9**			**3.8**			**5.3**			**9.0**	
Total Costs/kW					$30.89			$41.30			$51.78			$69.45	
Labor Costs/kW					$19.96			$26.15			$33.42			$45.35	
Equip.Mater Costs/kW					$10.92			$15.15			$18.36			$24.10	
Total Cost/Swept Area					$13.59			$18.17			$22.78			$30.56	
Man-Hours/Swept Area					0.18			0.24			0.31			0.42	
Labor Costs/Swept Area					$8.78			$11.51			$14.71			$19.95	
Equip, Mater Costs/Swept Area					$4.81			$6.67			$8.08			$10.61	
Total Costs/Hub Heigh					$542			$933			$1,376			$2,215	
Labor Costs/Hub Heigh					$350			$591			$888			$1,447	
Equip.Mater Costs/Hub Heigh					$192			$342			$488			$769	
Item 1 Hourly Rates				$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates				$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates				$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates				$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates				$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate				$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor				8%			5%			3%			3%		
Item 2 Percent of Labor				18%			15%			12%			11%		
Item 3 Percent of Labor				5%			4%			2%			2%		
Item 4 Percent of Labor				8%			6%			4%			3%		
Item 5 Percent of Labor				8%			10%			7%			6%		
Item 6 Percent of Labor				2%			1%			1%			1%		
Item 7 Percent of Labor				7%			4%			2%			4%		
Item 8 Percent of Labor				9%			9%			9%			9%		

Number of People in Crew:	10	75%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m)		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				40	$1,400		75	$2,625		96	$3,360		142	$4,970	
2. Fabricate Tower Assembly Area				12	$490	$1,160	12	$490	$1,160	12	$490	$1,160	12	$490	$1,160
3. Field Fabrication Tower Sections				212	$8,931	$6,163	642	$27,047	$18,772	1451	$60,306	$39,404	3080	$126,344	$75,743
4. Rig & Set Tower Sections				60	$2,100		110	$3,850		161	$5,635		282	$9,870	
5. Grout and Torque Bases				40	$1,400	$850	59	$2,065	$950	70	$2,450	$1,120	87	$3,045	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	57	$2,002	$250	87	$3,031	$500	101	$3,549	$700	147	$5,156	$1,000
7. Rig & Set Nacelle				22	$770		52	$2,537		68	$3,341		109	$5,205	
8. Install Safety Equipment				12	$420		20	$700		24	$840		36	$1,260	
9. General Conditions					$1,629	$4,285		$1,844	$8,092		$1,844	$8,092		$6,547	$15,706
10. Margin @ 10%					$1,914	$1,271		$4,419	$2,947		$8,182	$5,048		$16,289	$9,526
Subtotal Per Turbine				**456**	**$21,057**	**$13,979**	**1057**	**$48,607**	**$32,421**	**1984**	**$89,997**	**$55,523**	**3896**	**$179,175**	**$104,785**
Percent of Total					60%	40%		60%	40%		62%	38%		63%	37%
Project Total (50 Turbines)				**22784.881**	**$1,052,829**	**$698,926**	**52874**	**$2,430,374**	**$1,621,052**	**99214**	**$4,499,875**	**$2,776,153**	**194781**	**$8,958,728**	**$5,239,249**
Total All Costs					**$1,751,755**			**$4,051,426**			**$7,276,028**			**$14,197,977**	
Total Cost per Turbine					**$35,035**			**$81,029**			**$145,521**			**$283,960**	
Estimated Assembly Rate - Items 2,5 (Hours)					**82**			**162**			**229**			**391**	
Estimated Assembly Rate - Items 2,5 (Days)					**0.8**			**1.6**			**2.3**			**3.9**	
Total Costs/kW					$23.27			$32.45			$42.11			$57.06	
Labor Costs/kW					$13.99			$19.47			$26.04			$36.01	
Equip.Mater Costs/kW					$9.29			$12.99			$16.07			$21.06	
Total Cost/Swept Area					$10.24			$14.28			$18.53			$25.11	
Man-Hours/Swept Area					0.13			0.19			0.25			0.34	
Labor Costs/Swept Area					$6.15			$8.57			$11.46			$15.84	
Equip, Mater Costs/Swept Area					$4.09			$5.71			$7.07			$9.27	
Total Costs/Hub Height					$408			$733			$1,119			$1,820	
Labor Costs/Hub Height					$245			$440			$692			$1,149	
Equip.Mater Costs/Hub Height					$163			$293			$427			$672	
Item 1 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 2 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 3 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 4 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 5 Hourly Rates				$35.00			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Combined Hourly Rate				$51.35											
Item 1 Percent of Labor				7%			5%			4%			3%		
Item 2 Percent of Labor				10%			8%			6%			6%		
Item 3 Percent of Labor				7%			4%			3%			2%		
Item 4 Percent of Labor				10%			6%			4%			3%		
Item 5 Percent of Labor				4%			5%			4%			3%		
Item 6 Percent of Labor				2%			1%			1%			1%		
Item 7 Percent of Labor				8%			4%			2%			4%		
Item 8 Percent of Labor				9%			9%			9%			9%		

Number of People in Crew:	10	105%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				64	$2,579		75	$3,023		96	$3,869		142	$5,723	
2. Fabricate Tower Assembly Area				16	$626	$1,483	16	$626	$1,483	16	$626	$1,483	16	$626	$1,483
3. Field Fabrication Tower Sections				271	$11,412	$7,875	821	$34,560	$23,986	1855	$77,058	$50,349	3935	$161,440	$96,783
4. Rig & Set Tower Sections				138	$5,562		254	$10,236		371	$14,950		687	$27,535	
5. Grout and Torque Bases				40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	62	$2,487	$250	97	$3,905	$500	115	$4,633	$700	171	$6,900	$1,000
7. Rig & Set Nacelle				67	$2,724		155	$7,561		204	$10,024		348	$16,616	
8. Install Safety Equipment				12	$484		20	$806		24	$968		36	$1,450	
9. General Conditions					$2,281	$5,999		$2,582	$11,328		$2,582	$11,328		$9,165	$21,988
10. Margin @ 10%					$2,977	$1,646		$6,568	$3,825		$11,753	$6,498		$23,296	$12,290
Subtotal Per Turbine				**670**	**$32,743**	**$18,101**	**1497**	**$72,244**	**$42,072**	**2751**	**$129,286**	**$71,478**	**5422**	**$256,258**	**$135,194**
Percent of Total					64%	36%		63%	37%		64%	36%		65%	35%
Project Total (50 Turbines)				**33,478**	**$1,637,135**	**$905,069**	**74,835**	**$3,612,184**	**$2,103,586**	**137,525**	**$6,464,281**	**$3,573,896**	**271,125**	**$12,812,918**	**$6,759,687**
Total All Costs					**$2,542,204**			**$5,715,770**			**$10,038,177**			**$19,572,606**	
Total Cost per Turbine					**$50,844**			**$114,315**			**$200,764**			**$391,452**	
Estimated Assembly Rate - Items 2,5 (Hours)					**205**			**409**			**575**			**1,035**	
Estimated Assembly Rate - Items 2,5 (Days)					**2.1**			**4.1**			**5.8**			**10.4**	
Total Costs/kW					$33.78			$45.79			$58.10			$78.66	
Labor Costs/kW					$21.75			$28.93			$37.41			$51.50	
Equip.Mater Costs/kW					$12.02			$16.85			$20.68			$27.17	
Total Cost/Swept Area					$14.86			$20.15			$25.56			$34.61	
Man-Hours/Swept Area					0.20			0.26			0.35			0.48	
Labor Costs/Swept Area					$9.57			$12.73			$16.46			$22.66	
Equip, Mater Costs/Swept Area					$5.29			$7.41			$9.10			$11.95	
Total Costs/Hub Height					$593			$1,035			$1,544			$2,509	
Labor Costs/Hub Height					$382			$654			$995			$1,643	
Equip.Mater Costs/Hub Height					$211			$381			$550			$867	
Item 1 Hourly Rates				$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates				$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates				$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates				$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates				$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate				$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor				8%			4%			3%			2%		
Item 2 Percent of Labor				17%			14%			12%			11%		
Item 3 Percent of Labor				5%			3%			2%			1%		
Item 4 Percent of Labor				8%			5%			4%			3%		
Item 5 Percent of Labor				8%			10%			8%			6%		
Item 6 Percent of Labor				1%			1%			1%			1%		
Item 7 Percent of Labor				7%			4%			2%			4%		
Item 8 Percent of Labor				9%			9%			9%			9%		

WELDED QUARTER SECTIONS OF TOWERS

1. Tower section properties based on data in Table 2-2.
2. See Page N-3 for weight of weld.
3. Assumed manual weld rate: 8 lbs/hr

Weld weight - 1 inch steel	2.25	lb/ft
Welding rate	42.7	in/hr
Tower section length	21.5	m
Tower section length	846	in

Tower Section Assembly 1500 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0.00	$0	$160
Quarter-Section Weld	1693	INCHES	43	40	$40	$1,587	$0.58	$982	$2,569
Half-Section Weld	1693	INCHES	43	40	$40	$1,587	$0.58	$982	$2,569
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0.00	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0.00	$0	$320
Lifting Eyes	5.33	EA	1	5.33	$40	$213	$35.00	$187	$400
Paint	5000	SF	80	63	$40	$2,500	$0.50	$2,500	$5,000
Non-Productive Time	3%	MHRS		6	$40	$242	$0.00	$0	$242
X-RAY TEST	20	EA	1	20	$65	$1,300	$20.00	$400	$1,700
Weld Correction (1%)	34	INCHES	16	2	$40	$85	$0.58	$20	$104
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
Welding Equipment/Operating Costs	282	LF				$0	$6.30	$1,778	$1,778
TOTALS (PER SECTION)				**236**		**$9,924**		**$6,848**	**$16,771**
Minimum	**-10%**			**212**		**$8,931**		**$6,163**	**$15,094**
Maximum	**15%**			**271**		**$11,412**		**$7,875**	**$19,287**
Total Number of Sections in Turbine:			1	236		**$9,924**		**$6,848**	**$16,771**
Minimum			1	212		**$8,931**		**$6,163**	**$15,094**
Maximum			1	271		**$11,412**		**$7,875**	**$19,287**
	Avg	Min	Max						
10 People, 10 hrs/day	100	100	100						
Days per Tower Section	2.4	2.1	2.7						
Total number of sections for assembly	50	50	50						
Number of days for assembly	118	106	135						
Number of assembly days per turbine	2.4	2.1	2.7						
Number of 6 day weeks	19.6	17.7	22.6						

WELDED QUARTER SECTIONS OF TOWERS

1. Tower section properties based on data in Table 2-2.
2. See Page N-3 for weight of weld.
3. Assumed manual weld rate: 8 lbs/hr

Weld weight - 1 inch steel	2.25	lb/ft
Welding rate	42.7	in/hr
Tower section length	22.1	m
Tower section length	870	in

Tower Section Assembly 2500 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0.00	$0	$160
Quarter-Section Weld	1740	INCHES	42.7	41	$40	$1,631	$0.58	$1,009	$2,641
Half-Section Weld	1740	INCHES	42.7	41	$40	$1,631	$0.58	$1,009	$2,641
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0.00	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0.00	$0	$320
Lifting Eyes	5.33	EA	1	5.33	$40	$213	$35.00	$187	$400
Paint	5000	SF	80	63	$40	$2,500	$0.50	$2,500	$5,000
Non-Productive Time	3%	MHRS		6	$40	$245	$0.00	$0	$245
X-RAY TEST	20	EA	1	20	$65	$1,300	$20.00	$400	$1,700
Weld Correction (1%)	35	INCHES	16	2	$40	$87	$0.58	$20	$107
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
Welding Equipment/Operating Costs	290	LF				$0	$6.30	$1,827	$1,827
TOTALS (PER SECTION)				**238**		**$10,017**		**$6,952**	**$16,970**
Minimum	**-10%**			**214**		**$9,016**		**$6,257**	**$15,273**
Maximum	**15%**			**274**		**$11,520**		**$7,995**	**$19,515**
Total Number of Sections in Turbine:			3	714		**$30,052**		**$20,857**	**$50,909**
Minimum			3	642		**$27,047**		**$18,772**	**$45,818**
Maximum			3	821		**$34,560**		**$23,986**	**$58,546**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	2.4	2.1	2.7
Total number of sections for assembly	150	150	150
Number of days for assembly	357	321	410
Number of assembly days per turbine	7.1	6.4	8.2
Number of 6 day weeks	59.5	53.5	68.4

WELDED QUARTER SECTIONS OF TOWERS

1. Tower section properties based on data in Table 2-2.
2. See Page N-3 for weight of weld.
3. Assumed manual weld rate: 8 lbs/hr

Weld weight - 1.5 inch steel	4.6	lb/ft
Welding rate	20.9	in/hr
Tower section length	21.7	m
Tower section length	854	in

Tower Section Assembly 3500 MW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	20	EA	5	4	$40	$160	$0.00	$0	$160
Quarter-Section Weld	1709	INCHES	20.9	82	$40	$3,275	$0.58	$991	$4,266
Half-Section Weld	1709	INCHES	20.9	82	$40	$3,275	$0.58	$991	$4,266
Top & Bottom Template	10.67	EA	0.25	43	$40	$1,707	$0.00	$0	$1,707
Move Cradles	16	EA	2	8	$40	$320	$0.00	$0	$320
Lifting Eyes	5.33	EA	1	5.33	$40	$213	$35.00	$187	$400
Paint	5000	SF	80	63	$40	$2,500	$0.50	$2,500	$5,000
Non-Productive Time	3%	MHRS		9	$40	$344	$0.00	$0	$344
X-RAY TEST	20	EA	1	20	$65	$1,300	$20.00	$400	$1,700
Weld Correction (1%)	34	INCHES	16	2	$40	$85	$0.58	$20	$105
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
Welding Equipment/Operating Costs	285	LF				$0	$12.88	$3,668	$3,668
TOTALS (PER SECTION)				**323**		**$13,401**		**$8,756**	**$22,158**
Minimum	**-10%**			**290**		**$12,061**		**$7,881**	**$19,942**
Maximum	**15%**			**371**		**$15,412**		**$10,070**	**$25,481**
Total Number of Sections in Turbine:			5	1613		**$67,007**		**$43,782**	**$110,789**
Minimum			5	1451		**$60,306**		**$39,404**	**$99,710**
Maximum			5	1855		**$77,058**		**$50,349**	**$127,407**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	3.2	2.9	3.7
Total number of sections for assembly	250	250	250
Number of days for assembly	806	726	927
Number of assembly days per turbine	16.1	14.5	18.5
Number of 6-day weeks	134.4	121.0	154.5

WELDED QUARTER SECTIONS OF TOWERS

1. Tower section properties based on data in Table 2-2.
2. See Page N-3 for weight of weld.
3. Assumed manual weld rate: 8 lbs/hr

Weld weight - 2 inch steel	7.8	lb/ft
Welding rate	12.3	in/hr
Tower section length	22.3	m
Tower section length	878	in

Tower Section Assembly 5000 kW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	24	EA	4	6	$40	$240	$0.00	$0	$240
Quarter-Section Weld	1756	INCHES	12.3	143	$40	$5,707	$0.58	$1,018	$6,725
Half-Section Weld	1756	INCHES	12.3	143	$40	$5,707	$0.58	$1,018	$6,725
Top & Bottom Template	16	EA	0.25	64	$40	$2,560	$0.00	$0	$2,560
Move Cradles	24	EA	2	12	$40	$480	$0.00	$0	$480
Lifting Eyes	8	EA	1	8	$40	$320	$35.00	$280	$600
Paint	5788	SF	80	72	$40	$2,894	$0.50	$2,894	$5,788
Non-Productive Time	3%	MHRS		13	$40	$537	$0.00	$0	$537
X-RAY TEST	20	EA	1	20	$65	$1,300	$20.00	$400	$1,700
Weld Correction (1%)	35	INCHES	16	2	$40	$88	$0.58	$20	$108
Load & Transport Towers	1	SECTIONS	0.18	6	$40	$222	$0.00	$0	$222
	293	LF			$0	$0	$21.84	$6,391	$6,391
TOTALS (PER SECTION)				**489**		**$20,055**		**$12,023**	**$32,077**
Minimum	**-10%**			**440**		**$18,049**		**$10,820**	**$28,870**
Maximum	**15%**			**562**		**$23,063**		**$13,826**	**$36,889**
Total Number of Sections in Turbine:			7	3422		**$140,382**		**$84,159**	**$224,541**
Minimum			7	3080		**$126,344**		**$75,743**	**$202,087**
Maximum			7	3935		**$161,440**		**$96,783**	**$258,223**

	Avg	Min	Max
10 People, 10 hrs/day	100	100	100
Days per Tower Section	4.9	4.4	5.6
Total number of sections for assembly	350	350	350
Number of days for assembly	1711	1540	1968
Number of assembly days per turbine	34.2	30.8	39.4
Number of 6-day weeks	285.2	256.7	327.9

Turbine Class:	1,500			2,500			3,500			5000		
Rotor Diameter:	66			85			100			120		
Crane Type:	4100 S1			4100 S1			4600 S4			4600 S5		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Crane Crew Assembly Labor Costs/Turbine	$2,756	$3,063	$3,522	$8,351	$9,279	$10,671	$18,868	$20,965	$24,110	$40,038	$44,487	$51,160
Crane Crew Relocation Labor Costs/Turbine	0	0	0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Crane Rental Costs During Assembly and Relocation/Turbine	$1,223	$1,359	$1,563	$3,706	$4,118	$4,736	$17,864	$19,848	$22,826	$44,421	$49,357	$56,760
Meals and Lodging/Turbine	$318	$353	$406	$964	$1,071	$1,231	$2,177	$2,419	$2,782	$4,620	$5,133	$5,903
Fuel Cost/Turbine	$117	$130	$149	$353	$393	$451	$907	$1,008	$1,159	$1,925	$2,139	$2,460
Cribbing Costs/Turbine	$131	$131	$131	$131	$131	$131	$190	$190	$190	$595	$595	$595
Mob/Demob Costs/Turbine	$1,328	$1,328	$1,328	$1,328	$1,328	$1,328	$2,477	$2,477	$2,477	$2,757	$2,757	$2,757
Total Crane and Crew Costs/Turbine	**$5,873**	**$6,364**	**$7,100**	**$14,834**	**$16,320**	**$18,549**	**$42,483**	**$46,907**	**$53,543**	**$94,355**	**$104,467**	**$119,634**
Total Crane Costs (50 Turbines)	**$293,673**	**$318,197**	**$354,984**	**$741,688**	**$815,991**	**$927,447**	**$2,124,138**	**$2,345,339**	**$2,677,140**	**$4,717,770**	**$5,223,346**	**$5,981,711**
Costs/kW	$3.90	$4.23	$4.72	$5.94	$6.54	$7.43	$12.29	$13.57	$15.49	$18.96	$20.99	$24.04
Costs/Swept Area	$1.72	$1.86	$2.08	$2.61	$2.88	$3.27	$5.41	$5.97	$6.82	$8.34	$9.24	$10.58

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Tower Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	2.4	7.1	16.1	34.2
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	47.1	142.8	322.5	684.4
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$3,063	$9,279	$20,965	$44,487
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	2.4	7.1	16.1	34.2
Total Number of Days Required:	118	357	806	1711
Total Number of Weeks Required	19.6	59.5	134.4	285.2
Total Number of Months for Assembly	**4.5**	**13.7**	**31.0**	**65.8**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$67,960	$205,904	$992,418	$2,467,831
Crane Rental Costs/Turbine	$1,359	$4,118	$19,848	$49,357
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	235.5929717	713.7990923	1612.679015	3422.059357
Total Meals and Lodging Costs	$17,669	$53,535	$120,951	$256,654
Meals and Lodging/Turbine	$353	$1,071	$2,419	$5,133
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$6,479	$19,629	$50,396	$106,939
Fuel Cost/Turbine	$130	$393	$1,008	$2,139
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	2.1	6.4	14.5	30.8
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	42.4	128.5	290.3	616.0
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$2,756	$8,351	$18,868	$40,038
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	2.1	6.4	14.5	30.8
Total Number of Days Required:	106	321	726	1540
Total Number of Weeks Required	17.7	53.5	121.0	256.7
Total Number of Months for Assembly	**4.1**	**12.4**	**27.9**	**59.2**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$61,164	$185,313	$893,176	$2,221,048
Crane Rental Costs/Turbine	$1,223	$3,706	$17,864	$44,421
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	212.0336745	642.419183	1451.411114	3079.853422
Total Meals and Lodging Costs	$15,903	$48,181	$108,856	$230,989
Meals and Lodging/Turbine	$318	$964	$2,177	$4,620
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$5,831	$17,667	$45,357	$96,245
Fuel Cost/Turbine	$117	$353	$907	$1,925
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Initial Assumptions		Tower Fabrication	Crane Assembly	
Work Hours/Day		10	8	
Number of Days/Wk		6	5	
Number of Weeks/Year		52	52	
Number of Weeks/Month		4.3333	4.4000	
Number of Days/Month		26	22	
Number of Hours/Month		260	176	
Number of Turbines		50		
Turbine Rating (kW)	1500	2500	3500	5000
Crane Type	4100 S1	4100 S1	4600 S4	4600 S5
Monthly Crane Costs during turbine assembly (60hr week)	$15,000	$15,000	$32,000	$37,500
Monthly crane costs other time	$15,000	$15,000	$32,000	$37,500
6 Month Rental Costs	$14,000	$14,000	$29,867	$35,000
9 Month Rental Costs	$13,500	$13,500	$28,800	$33,750
12 Month Rental Costs	$13,000	$13,000	$27,733	$32,500
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)				
Number of People in Crew	10	10	10	10
Number of Crews	1	1	1	1
Man Hours/Day	100	100	100	100
Number of Man Hours/Wk	600	600	600	600
Tower Fabrication Assembly Rate Days/Turbine	2.7	8.2	18.5	39.4
2. Crane Crew Information - During Tower Assembly				
Number of People in Crane Crew	2	2	2	2
Number of Cranes and Crew	1	1	1	1
Number of Turbines/Crane	50	50	50	50
Man Hours/Day	20	20	20	20
Estimated Crane Crew Man Hours/Turbine	54.2	164.2	370.9	787.1
Labor Costs/Crane Crew Man Hour	$65	$65	$65	$65
Crane Crew Assembly Labor Costs/Turbine	$3,522	$10,671	$24,110	$51,160
3. Crane Relocation Information				
Estimated Relocation Hours/Turbine	0	0	0	0
Total Relocation Hours	0	0	0	0
Total Relocation Hours/Crane	0	0	0	0
Relocation Days/Crane	0	0	0	0
Estimated Relocation Days/Turbine	0	0	0	0
Crane Crew Relocation Man Hours/Turbine	0.0	0.0	0.0	0.0
Crane Crew Relocation Labor Costs/Turbine	$0	$0	$0	$0
Crane Costs During Relocation/Turbine	$0	$0	$0	$0
3. Totals				
Total Number of Tower Fabrication Days/Turbine	2.7	8.2	18.5	39.4
Total Number of Days Required:	135	410	927	1968
Total Number of Weeks Required	22.6	68.4	154.5	327.9
Total Number of Months for Assembly	**5.2**	**15.8**	**35.7**	**75.7**
3 Month Min Crane Rental Costs	$45,000	$45,000	$96,000	$112,500
Total Crane Rental Charges	$78,153	$236,789	$1,141,281	$2,838,006
Crane Rental Costs/Turbine	$1,563	$4,736	$22,826	$56,760
4. Material/Supplies/Incidental Crane Costs				
Meals and Lodging/Person/Day	$75	$75	$75	$75
Number of Person-Days	270.9319175	820.8689561	1854.580868	3935.368261
Total Meals and Lodging Costs	$20,320	$61,565	$139,094	$295,153
Meals and Lodging/Turbine	$406	$1,231	$2,782	$5,903
5. Fuel				
Fuel Cost/Gallon	$1.50	$1.50	$1.50	$1.50
Gallons of Fuel/Week	220	220	250	250
Total Cost of Fuel	$7,451	$22,574	$57,956	$122,980
Fuel Cost/Turbine	$149	$451	$1,159	$2,460
6. Cribbing				
Cribbing Cost/sq ft	$2.50	$2.50	$2.50	$2.50
Required Cribbing sq ft/Turbine	2615	2615	3800	11900
Cribbing Costs/Turbine	$131	$131	$190	$595
7. Mobilization and Demobilization				
Crane Assembly and Disassembly Hours	24	24	48	48
Lampson Supervisor Hours	24	24	48	48
Lampson Supervisor Hourly Cost	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4
Man Hours for Iron Workers	96	96	192	192
Iron Worker Hourly Cost	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.1	0.3	0.3
Crane Rental Cost	$2,045	$2,045	$8,727	$10,227
Total Labor Costs	$8,040	$8,040	$16,080	$16,080
Truck Crane 1 Hourly Cost	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325
Truck Crane 3 Hourly Costs				
Total Truck Crane Costs	$12,240	$12,240	$24,480	$24,480
Total Transportation Freight in/out	$40,000	$40,000	$60,000	$70,000
Transport Days in/out	6	6	10	10
Transport Hours in/out	48	48	80	80
Crane Rental During Transport	$4,091	$4,091	$14,545	$17,045
SubTotal	$66,416	$66,416	$123,833	$137,833
Mob/Demob Costs/Turbine	$1,328	$1,328	$2,477	$2,757

Appendix M
Scenario 3

Number of People in Crew:	10	100%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				62	$2,498		75	$3,023		96	$3,869		142	$5,723	
2. Fabricate Tower Assembly Area				14	$544	$1,289	14	$544	$1,289	14	$544	$1,289	14	$544	$1,289
3. Field Fabrication Tower Sections				101	$4,135	$6,621	333	$13,647	$20,701	588	$24,142	$34,315	952	$39,128	$51,509
4. Rig & Set Tower Sections				132	$5,320		243	$9,793		354	$14,265		619	$24,810	
5. Grout and Torque Bases				40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	61	$2,447	$250	95	$3,816	$500	112	$4,513	$700	164	$6,626	$1,000
7. Rig & Set Nacelle				57	$2,317		133	$6,488		174	$8,550		280	$13,370	
8. Install Gearbox and Generator in Nacelle - on tower							60	$2,927		90	$4,422		120	$5,730	
9. Install Safety Equipment				12	$484		20	$806		24	$968		36	$1,450	
10. General Conditions					$2,172	$5,713		$2,459	$10,789		$2,459	$10,789		$8,729	$20,941
11. Margin @ 10%					$2,153	$1,472		$4,588	$3,423		$6,655	$4,821		$10,962	$7,639
Subtotal Per Turbine				**479**	**$23,682**	**$16,195**	**1032**	**$50,468**	**$37,652**	**1522**	**$73,209**	**$53,034**	**2414**	**$120,577**	**$84,028**
Percent of Total					59%	41%		57%	43%		58%	42%		59%	41%
Project Total (50 Turbines)				**23947**	**$1,184,123**	**$809,752**	**51596**	**$2,523,401**	**$1,882,619**	**76116**	**$3,660,453**	**$2,651,696**	**120721**	**$6,028,843**	**$4,201,393**
Total All Costs					**$1,993,875**			**$4,406,020**			**$6,312,150**			**$10,230,235**	
Total Cost per Turbine					**$39,878**			**$88,120**			**$126,243**			**$204,605**	
Estimated Assembly Rate - Items 2,5 (Hours)					**189**			**436**			**618**			**1,019**	
Estimated Assembly Rate - Items 2,5 (Days)					**1.9**			**4.4**			**6.2**			**10.2**	
Total Costs/kW					$26.49			$35.29			$36.53			$41.12	
Labor Costs/kW					$15.73			$20.21			$21.18			$24.23	
Equip.Mater Costs/kW					$10.76			$15.08			$15.35			$16.89	
Total Cost/Swept Area					$11.66			$15.53			$16.07			$18.09	
Man-Hours/Swept Area					0.14			0.18			0.19			0.21	
Labor Costs/Swept Area					$6.92			$8.89			$9.32			$10.66	
Equip, Mater Costs/Swept Area					$4.73			$6.64			$6.75			$7.43	
Total Costs/Hub Height					$465			$797			$971			$1,312	
Labor Costs/Hub Height					$276			$457			$563			$773	
Equip.Mater Costs/Hub Height					$189			$341			$408			$539	
Item 1 Hourly Rates				$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates				$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates				$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates				$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates				$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate				$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor				11%			6%			5%			5%		
Item 2 Percent of Labor				22%			19%			19%			21%		
Item 3 Percent of Labor				7%			5%			4%			3%		
Item 4 Percent of Labor				10%			8%			6%			5%		
Item 5 Percent of Labor				10%			13%			12%			11%		
Item 6 Percent of Labor				2%			2%			1%			1%		
Item 7 Percent of Labor				9%			5%			3%			7%		
Item 8 Percent of Labor				9%			9%			9%			9%		

Number of People in Crew:	10	75%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m)		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				40	$1,400		75	$2,625		96	$3,360		142	$4,970	
2. Fabricate Tower Assembly Area				12	$490	$1,160	12	$490	$1,160	12	$490	$1,160	12	$490	$1,160
3. Field Fabrication Tower Sections				91	$3,722	$5,959	300	$12,282	$18,631	530	$21,728	$30,883	857	$35,215	$46,358
4. Rig & Set Tower Sections				60	$2,100		110	$3,850		161	$5,635		282	$9,870	
5. Grout and Torque Bases				40	$1,400	$850	59	$2,065	$950	70	$2,450	$1,120	87	$3,045	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	57	$2,002	$250	87	$3,031	$500	101	$3,549	$700	147	$5,156	$1,000
7. Rig & Set Nacelle				22	$770		52	$2,537		68	$3,341		109	$5,205	
8. Install Gearbox and Generator in Nacelle - on tower							60	$2,927		90	$4,422		120	$5,730	
9. Install Safety Equipment				12	$420		20	$700		24	$840		36	$1,260	
10. General Conditions					$1,629	$4,285		$1,844	$8,092		$1,844	$8,092		$6,547	$15,706
11. Margin @ 10%					$1,393	$1,250		$3,235	$2,933		$4,766	$4,196		$7,749	$6,587
Subtotal Per Turbine				**335**	**$15,326**	**$13,754**	**775**	**$35,586**	**$32,266**	**1152**	**$52,425**	**$46,151**	**1793**	**$85,235**	**$72,461**
Percent of Total					53%	47%		52%	48%		53%	47%		54%	46%
Project Total (50 Turbines)				**16746**	**$766,296**	**$687,695**	**38755**	**$1,779,285**	**$1,613,323**	**57624**	**$2,621,267**	**$2,307,527**	**89636**	**$4,261,757**	**$3,623,065**
Total All Costs					**$1,453,991**			**$3,392,608**			**$4,928,794**			**$7,884,822**	
Total Cost per Turbine					**$29,080**			**$67,852**			**$98,576**			**$157,696**	
Estimated Assembly Rate - Items 2,5 (Hours)					**82**			**222**			**319**			**511**	
Estimated Assembly Rate - Items 2,5 (Days)					**0.8**			**2.2**			**3.2**			**5.1**	
Total Costs/kW					$19.32			$27.18			$28.53			$31.69	
Labor Costs/kW					$10.18			$14.25			$15.17			$17.13	
Equip.Mater Costs/kW					$9.14			$12.92			$13.35			$14.56	
Total Cost/Swept Area					$8.50			$11.96			$12.55			$13.94	
Man-Hours/Swept Area					0.10			0.14			0.15			0.16	
Labor Costs/Swept Area					$4.48			$6.27			$6.68			$7.54	
Equip, Mater Costs/Swept Area					$4.02			$5.69			$5.88			$6.41	
Total Costs/Hub Height					$339			$614			$758			$1,011	
Labor Costs/Hub Height					$179			$322			$403			$546	
Equip.Mater Costs/Hub Height					$160			$292			$355			$464	
Item 1 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 2 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 3 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 4 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Item 5 Hourly Rates				$35.00			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$35.00			$35.00			$35.00			$35.00		
Combined Hourly Rate				$51.35											
Item 1 Percent of Labor				9%			7%			6%			6%		
Item 2 Percent of Labor				14%			11%			11%			12%		
Item 3 Percent of Labor				9%			6%			5%			4%		
Item 4 Percent of Labor				13%			9%			7%			6%		
Item 5 Percent of Labor				5%			7%			6%			6%		
Item 6 Percent of Labor				3%			2%			2%			1%		
Item 7 Percent of Labor				11%			5%			4%			8%		
Item 8 Percent of Labor				9%			9%			9%			9%		

Number of People in Crew:	10	105%													
Hours per Day:	10														
Days per Week	6														
Turbine Rating (kW):		**750**			**1500**			**2500**			**3500**			**5000**	
Rotor Diameter (m):		**50**			**66**			**85**			**100**			**120**	
Activity	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material	MHRS	Labor Costs	Equip & Material
1. Receive, Uncrate Nacelle, Blades, Rotors & Towers				64	$2,579		75	$3,023		96	$3,869		142	$5,723	
2. Fabricate Tower Assembly Area				16	$626	$1,483	16	$626	$1,483	16	$626	$1,483	16	$626	$1,483
3. Field Fabrication Tower Sections				117	$4,755	$7,614	383	$15,694	$23,807	677	$27,763	$39,462	1095	$44,997	$59,235
4. Rig & Set Tower Sections				138	$5,562		254	$10,236		371	$14,950		687	$27,535	
5. Grout and Torque Bases				40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	$3,506	$1,650
6. Rig Blades, Assemble Rotors In Air	43	$1,733	$150	62	$2,487	$250	97	$3,905	$500	115	$4,633	$700	171	$6,900	$1,000
7. Rig & Set Nacelle				67	$2,724		155	$7,561		204	$10,024		348	$16,616	
8. Install Gearbox and Generator in Nacelle - on tower							60	$2,927		90	$4,422		120	$5,730	
9. Install Safety Equipment				12	$484		20	$806		24	$968		36	$1,450	
10. General Conditions					$2,281	$5,999		$2,582	$11,328		$2,582	$11,328		$9,165	$21,988
11. Margin @ 10%					$2,311	$1,619		$4,974	$3,807		$7,266	$5,409		$12,225	$8,536
Subtotal Per Turbine				**515**	**$25,420**	**$17,814**	**1119**	**$54,710**	**$41,874**	**1663**	**$79,926**	**$59,502**	**2702**	**$134,474**	**$93,891**
Percent of Total					59%	41%		57%	43%		57%	43%		59%	41%
Project Total (50 Turbines)				**25762**	**$1,271,009**	**$890,719**	**55960**	**$2,735,522**	**$2,093,710**	**83133**	**$3,996,277**	**$2,975,096**	**135106**	**$6,723,695**	**$4,694,564**
Total All Costs					**$2,161,728**			**$4,829,232**			**$6,971,373**			**$11,418,258**	
Total Cost per Turbine					**$43,235**			**$96,585**			**$139,427**			**$228,365**	
Estimated Assembly Rate - Items 2,5 (Hours)					**205**			**469**			**665**			**1,155**	
Estimated Assembly Rate - Items 2,5 (Days)					**2.1**			**4.7**			**6.7**			**11.6**	
Total Costs/kW					$28.72			$38.68			$40.35			$45.89	
Labor Costs/kW					$16.89			$21.91			$23.13			$27.02	
Equip.Mater Costs/kW					$11.83			$16.77			$17.22			$18.87	
Total Cost/Swept Area					$12.64			$17.02			$17.75			$20.19	
Man-Hours/Swept Area					0.15			0.20			0.21			0.24	
Labor Costs/Swept Area					$7.43			$9.64			$10.18			$11.89	
Equip, Mater Costs/Swept Area					$5.21			$7.38			$7.58			$8.30	
Total Costs/Hub Height					$504			$874			$1,073			$1,464	
Labor Costs/Hub Height					$296			$495			$615			$862	
Equip.Mater Costs/Hub Height					$208			$379			$458			$602	
Item 1 Hourly Rates				$40.30			$40.31			$40.30			$40.30		
Item 2 Hourly Rates				$40.30			$40.30			$40.30			$40.08		
Item 3 Hourly Rates				$40.30			$40.29			$40.31			$40.30		
Item 4 Hourly Rates				$40.31			$40.30			$40.29			$40.31		
Item 5 Hourly Rates				$40.65			$48.78			$49.14			$47.75		
Item 6 Hourly Rates				$40.33			$40.30			$40.33			$40.28		
Combined Hourly Rate				$51.35			$54.58			$52.70			$57.38		
Item 1 Percent of Labor				10%			6%			5%			4%		
Item 2 Percent of Labor				22%			19%			19%			20%		
Item 3 Percent of Labor				6%			4%			4%			3%		
Item 4 Percent of Labor				10%			7%			6%			5%		
Item 5 Percent of Labor				11%			14%			13%			12%		
Item 6 Percent of Labor				2%			1%			1%			7%		
Item 7 Percent of Labor				9%			5%			3%			#REF!		
Item 8 Percent of Labor				9%			9%			9%			9%		

Turbine Class:	2500			3500			5000		
Rotor Diameter:	85			100			120		
Crane Type:	**LTL-850**			**LTL-1100**			**LTL-1200**		
	Min	**Avg**	**Max**	Min	Avg	Max	Min	Avg	Max
Crane Crew Assembly Labor Costs/Turbine	$4,290	$8,580	$9,165	$6,240	$12,090	$13,065	$9,945	$19,890	$22,620
Crane Crew Relocation Labor Costs/Turbine	$2,730	$2,730	$2,730	$4,875	$4,875	$4,875	$6,435	$6,435	$6,435
Crane Rental Costs During Assembly and Reloca	$12,923	$20,821	$21,897	$27,623	$42,162	$44,585	$49,000	$78,750	$86,917
Meals and Lodging/Turbine	$810	$1,305	$1,373	$1,283	$1,958	$2,070	$1,890	$3,038	$3,353
Fuel Cost/Turbine	$585	$943	$991	$998	$1,523	$1,610	$1,575	$2,531	$2,794
Cribbing Costs/Turbine	$538	$538	$538	$943	$943	$943	$943	$943	$943
Mob/Demob Costs/Turbine	$9,695	$9,695	$9,695	$22,141	$22,141	$22,141	$32,116	$32,116	$32,116
Total Crane and Crew Costs/Turbine	**$31,570**	**$44,610**	**$46,388**	**$64,101**	**$85,690**	**$89,288**	**$101,903**	**$143,702**	**$155,176**
Total Crane Costs (50 Turbines)	**$1,578,506**	**$2,230,503**	**$2,319,411**	**$3,205,065**	**$4,284,488**	**$4,464,392**	**$5,095,157**	**$7,185,094**	**$7,758,802**
Costs/kW	$12.64	$17.87	$18.58	$18.55	$24.80	$25.84	$20.48	$28.88	$31.18
Costs/Swept Area	$5.56	$7.86	$8.17	$8.16	$10.91	$11.37	$9.01	$12.71	$13.72

Initial Assumptions	Turbine Assembly	Crane Assembly								
Work Hours/Day	10	8								
Number of Days/Wk	6	5								
Number of Weeks/Year	52	52								
Number of Weeks/Month	4.3333	4.4000								
Number of Days/Month	26	22								
Number of Hours/Month	260	176								
Number of Turbines	50									
Turbine Rating (kW)	750			1500		2500	3500		5000	
Crane Type						**LTL-850**		**LTL-1100**		**LTL-1200**
Monthly Crane Costs during turbine assembly (60hr wk)						$100,000		$140,000		$175,000
Monthly crane costs other time						$100,000		$140,000		$175,000
6 Month Rental Costs						$93,333		$130,667		$163,333
9 Month Rental Costs						$90,000		$126,000		$157,500
12 Month Rental Costs						$86,667		$121,333		$151,667
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)										
Number of People in Crew						10		10		10
Number of Crews						1		1		1
Man Hours/Day						100		100		100
Number of Man Hours/Wk						600		600		600
Crane Assembly Rate Days/Turbine						4.4		6.2		10.2
2. Crane Crew Information - During Turbine Assembly										
Number of People in Crane Crew						3		3		3
Number of Cranes and Crew						1		1		1
Number of Turbines/Crane						50		50		50
Man Hours/Day						30		30		30
Estimated Crane Crew Man Hours/Turbine						132		186		306
Labor Costs/Crane Crew Man Hour						$65		$65		$65
Crane Crew Assembly Labor Costs/Turbine						$8,580		$12,090		$19,890
3. Crane Relocation Information										
Estimated Relocation Hours/Turbine						14		25		33
Total Relocation Hours						700		1250		1650
Total Relocation Hours/Crane						700		1250		1650
Relocation Days/Crane						70		125		165
Estimated Relocation Days/Turbine						1.4		2.5		3.3
Crane Crew Relocation Man Hours/Turbine						42.0		75.0		99.0
Crane Crew Relocation Labor Costs/Turbine						$2,730		$4,875		$6,435
Crane Costs During Relocation/Turbine						$0		$0		$0
3. Totals										
Total Number of Crane Assembly Days/Turbine						5.80		8.70		13.5
Total Number of Days Required:						290		435		675
Total Number of Weeks Required						48.3		72.5		112.5
Installed kW per Day						431		402		370
Total Number of Months for Assembly						**11.2**		**16.7**		**26.0**
3 Month Min Crane Rental Costs						$300,000		$420,000		$525,000
Total Crane Rental Charges						$1,041,025		$2,108,077		$3,937,500
Crane Rental Costs/Turbine						$20,821		$42,162		$78,750
4. Material/Supplies/Incidental Crane Costs										
Meals and Lodging/Person/Day						$75		$75		$75
Number of Person-Days						870		1305		2025
Total Meals and Lodging Costs						$65,250		$97,875		$151,875
Meals and Lodging/Turbine						$1,305		$1,958		$3,038
5. Fuel										
Fuel Cost/Gallon						$1.50		$1.50		$1.50
Gallons of Fuel/Week						650		700		750
Total Cost of Fuel						$47,125		$76,125		$126,563
Fuel Cost/Turbine						$943		$1,523		$2,531
6. Cribbing										
Cribbing Cost/sq ft						$2.50		$2.50		$2.50
Required Cribbing sq ft/Turbine						10,750		18,850		18,850
Cribbing Costs/Turbine						$538		$943		$943
7. Mobilization and Demobilization										
Crane Assembly and Disassembly Hours						192		360		480
Lampson Supervisor Hours						192		360		480
Lampson Supervisor Hourly Cost						$75		$75		$75
Number of Iron Workers						6		8		10
Man Hours for Iron Workers						1152		2880		4800
Iron Worker Hourly Cost						$65		$65		$65
Crane Rental Period (Months) During Assembly						1.1		2.0		2.7
Crane Rental Cost						$109,091		$286,364		$477,273
Total Labor Costs						$89,280		$214,200		$348,000
Truck Crane 1 Hourly Cost						$185		$185		$185
Truck Crane 2 Hourly Cost						$350		$350		$400
Truck Crane 3 Hourly Costs								$185		$185
Total Truck Crane Costs						$102,720		$259,200		$369,600
Total Transportation Freight in/out						$120,000		$220,000		$220,000
Transport Days in/out						14		20		24
Transport Hours in/out						112		160		192
Crane Rental During Transport						$63,636		$127,273		$190,909
SubTotal						$484,727		$1,107,036		$1,605,782
Mob/Demob Costs/Turbine						$9,695		$22,141		$32,116

Initial Assumptions	Turbine Assembly	Crane Assembly								
Work Hours/Day	10	8								
Number of Days/Wk	6	5								
Number of Weeks/Year	52	52								
Number of Weeks/Month	4.3333	4.4000								
Number of Days/Month	26	22								
Number of Hours/Month	260	176								
Number of Turbines	50									
Turbine Rating (kW)						2500		3500	5000	
Crane Type						**LTL-850**		**LTL-1100**		**LTL-1200**
Monthly Crane Costs during turbine assembly (60hr wk)						$100,000		$140,000		$175,000
Monthly crane costs other time						$100,000		$140,000		$175,000
6 Month Rental Costs						$93,333		$130,667		$163,333
9 Month Rental Costs						$90,000		$126,000		$157,500
12 Month Rental Costs						$86,667		$121,333		$151,667
1. Assembly Crew Information - (Assembly crew produciton rate determines crane production and costs)										
Number of People in Crew						10		10		10
Number of Crews						1		1		1
Man Hours/Day						100		100		100
Number of Man Hours/Wk						600		600		600
Crane Assembly Rate Days/Turbine						2.2		3.2		5.1
2. Crane Crew Information - During Turbine Assembly										
Number of People in Crane Crew						3		3		3
Number of Cranes and Crew						1		1		1
Number of Turbines/Crane						50		50		50
Man Hours/Day						30		30		30
Estimated Crane Crew Man Hours/Turbine						66		96		153
Labor Costs/Crane Crew Man Hour						$65		$65		$65
Crane Crew Assembly Labor Costs/Turbine	$325	$325	$1,170	$910	$1,365	$4,290	$4,193	$6,240	$9,263	$9,945
3. Crane Relocation Information										
Estimated Relocation Hours/Turbine						14		25		33
Total Relocation Hours						700		1250		1650
Total Relocation Hours/Crane						700		1250		1650
Relocation Days/Crane						70		125		165
Estimated Relocation Days/Turbine						1.4		2.5		3.3
Crane Crew Relocation Man Hours/Turbine						42.0		75.0		99.0
Crane Crew Relocation Labor Costs/Turbine	$780	$780	$780	$1,040	$1,560	$2,730	$4,095	$4,875	$4,875	$6,435
Crane Costs During Relocation/Turbine						$0		$0		$0
3. Totals										
Total Number of Crane Assembly Days/Turbine						3.60		5.70		8.40
Total Number of Days Required:						180		285		420
Total Number of Weeks Required						30.0		47.5		70.0
Installed kW per Day						694		614		595
Total Number of Months for Assembly						**6.9**		**11.0**		**16.2**
3 Month Min Crane Rental Costs						$300,000		$420,000		$525,000
Total Crane Rental Charges						$646,154		$1,381,154		$2,450,000
Crane Rental Costs/Turbine	$900	$1,920	$2,250	$4,200	$5,400	$12,923	$18,389	$27,623	$33,833	$49,000
4. Material/Supplies/Incidental Crane Costs										
Meals and Lodging/Person/Day						$75		$75		$75
Number of Person-Days						540		855		1260
Total Meals and Lodging Costs						$40,500		$64,125		$94,500
Meals and Lodging/Turbine	$128	$128	$225	$225	$338	$810	$956	$1,283	$1,631	$1,890
5. Fuel										
Fuel Cost/Gallon						$1.50		$1.50		$1.50
Gallons of Fuel/Week						650		700		750
Total Cost of Fuel						$29,250		$49,875		$78,750
Fuel Cost/Turbine	$47	$53	$94	$94	$244	$585	$744	$998	$1,269	$1,575
6. Cribbing										
Cribbing Cost/sq ft						$2.50		$2.50		$2.50
Required Cribbing sq ft/Turbine						10750		18850		18850
Cribbing Costs/Turbine	$131	$190	$595	$595	$808	$538	$808	$943	$943	$943
7. Mobilization and Demobilization										
Crane Assembly and Disassembly Hours						192		360		480
Lampson Supervisor Hours						192		360		480
Lampson Supervisor Hourly Cost						$75		$75		$75
Number of Iron Workers						6		8		10
Man Hours for Iron Workers						1152		2880		4800
Iron Worker Hourly Cost						$65		$65		$65
Crane Rental Period (Months) During Assembly						1.1		2.0		2.7
Crane Rental Cost						$109,091		$286,364		$477,273
Total Labor Costs						$89,280		$214,200		$348,000
Truck Crane 1 Hourly Cost						$185		$185		$185
Truck Crane 2 Hourly Cost						$350		$350		$400
Truck Crane 3 Hourly Costs								$185		$185
Total Truck Crane Costs						$102,720		$259,200		$369,600
Total Transportation Freight in/out						$120,000		$220,000		$220,000
Transport Days in/out						14		20		24
Transport Hours in/out						112		160		192
Crane Rental During Transport						$63,636		$127,273		$190,909
SubTotal						$484,727		$1,107,036		$1,605,782
Mob/Demob Costs/Turbine	$1,328	$2,477	$2,757	$4,225	$8,302	$9,695	$19,522	$22,141	$22,650	$32,116

Initial Assumptions	Turbine Assembly	Crane Assembly								
Work Hours/Day	10	8								
Number of Days/Wk	6	5								
Number of Weeks/Year	52	52								
Number of Weeks/Month	4.3333	4.4000								
Number of Days/Month	26	22								
Number of Hours/Month	260	176								
Number of Turbines	50									
Turbine Rating (kW)						2500		3500		5000
Crane Type						**LTL-850**		**LTL-1100**		**LTL-1200**
Monthly Crane Costs during turbine assembly (60hr week)						$100,000		$140,000		$175,000
Monthly crane costs other time						$100,000		$140,000		$175,000
6 Month Rental Costs						$93,333		$130,667		$163,333
9 Month Rental Costs						$90,000		$126,000		$157,500
12 Month Rental Costs						$86,667		$121,333		$151,667
1. Assembly Crew Information - (Assembly crew production rate determines crane production and costs)										
Number of People in Crew						10		10		10
Number of Crews						1		1		1
Man Hours/Day						100		100		100
Number of Man Hours/Wk						600		600		600
Crane Assembly Rate Days/Turbine						4.7		6.7		11.6
2. Crane Crew Information - During Turbine Assembly										
Number of People in Crane Crew						3		3		3
Number of Cranes and Crew						1		1		1
Number of Turbines/Crane						50		50		50
Man Hours/Day						30		30		30
Estimated Crane Crew Man Hours/Turbine						141		201		348
Labor Costs/Crane Crew Man Hour						$65		$65		$65
Crane Crew Assembly Labor Costs/Turbine	$715	$715	$1,885	$1,625	$2,438	$9,165	$7,118	$13,065	$15,308	$22,620
3. Crane Relocation Information										
Estimated Relocation Hours/Turbine						14		25		33
Total Relocation Hours						700		1250		1650
Total Relocation Hours/Crane						700		1250		1650
Relocation Days/Crane						70		125		165
Estimated Relocation Days/Turbine						1.4		2.5		3.3
Crane Crew Relocation Man Hours/Turbine						42.0		75.0		99.0
Crane Crew Relocation Labor Costs/Turbine	$780	$780	$780	$1,040	$1,560	$2,730	$4,095	$4,875	$4,875	$6,435
Crane Costs During Relocation/Turbine						$0		$0		$0
3. Totals										
Total Number of Crane Assembly Days/Turbine						6.10		9.20		14.90
Total Number of Days Required:						305		460		745
Total Number of Weeks Required						50.8		76.7		124.2
Installed kW per Day						410		380		336
Total Number of Months for Assembly						**11.7**		**17.7**		**28.7**
3 Month Min Crane Rental Costs						$300,000		$420,000		$525,000
Total Crane Rental Charges						$1,094,871		$2,229,231		$4,345,833
Crane Rental Costs/Turbine	$900	$1,920	$2,957	$5,519	$7,096	$21,897	$24,880	$44,585	$48,300	$86,917
4. Material/Supplies/Incidental Crane Costs										
Meals and Lodging/Person/Day						$75		$75		$75
Number of Person-Days						915		1380		2235
Total Meals and Lodging Costs						$68,625		$103,500		$167,625
Meals and Lodging/Turbine	$173	$173	$308	$308	$461	$1,373	$1,294	$2,070	$2,329	$3,353
5. Fuel										
Fuel Cost/Gallon						$1.50		$1.50		$1.50
Gallons of Fuel/Week						650		700		750
Total Cost of Fuel						$49,563		$80,500		$139,688
Fuel Cost/Turbine	$63	$72	$128	$128	$333	$991	$1,006	$1,610	$1,811	$2,794
6. Cribbing										
Cribbing Cost/sq ft						$2.50		$2.50		$2.50
Required Cribbing sq ft/Turbine						10750		18850		18850
Cribbing Costs/Turbine	$131	$190	$595	$595	$808	$538	$808	$943	$943	$943
7. Mobilization and Demobilization										
Crane Assembly and Disassembly Hours						192		360		480
Lampson Supervisor Hours						192		360		480
Lampson Supervisor Hourly Cost						$75		$75		$75
Number of Iron Workers						6		8		10
Man Hours for Iron Workers						1152		2880		4800
Iron Worker Hourly Cost						$65		$65		$65
Crane Rental Period (Months) During Assembly						1.1		2.0		2.7
Crane Rental Cost						$109,091		$286,364		$477,273
Total Labor Costs						$89,280		$214,200		$348,000
Truck Crane 1 Hourly Cost						$185		$185		$185
Truck Crane 2 Hourly Cost						$350		$350		$400
Truck Crane 3 Hourly Costs								$185		$185
Total Truck Crane Costs						$102,720		$259,200		$369,600
Total Transportation Freight in/out						$120,000		$220,000		$220,000
Transport Days in/out						14		20		24
Transport Hours in/out						112		160		192
Crane Rental During Transport						$63,636		$127,273		$190,909
SubTotal						$484,727		$1,107,036		$1,605,782
Mob/Demob Costs/Turbine	$1,328	$2,477	$2,757	$4,225	$8,302	$9,695	$19,522	$22,141	$22,650	$32,116

Appendix N
Loaded Crane Rates and Assembly Work Pads

Turbine			750			1500		2500	3500		5000	
Crane Type			4100 S1	4600 S4	4600 S5	What If	LTL-600	LTL-850	LTL-1000	LTL-1100	LTL-1100	LTL-1200
Bare operation Rate	Per month		$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
Standby Rate	Per month		$10,000	$24,000	$25,000	$46,667	$60,000	$66,666	$83,333	$93,333	$93,333	$116,667
OT Rate (in addition to Base)	per month		$10,000	$21,333	$25,000	$46,667	$60,000	$66,667	$83,333	$93,333	$93,333	$116,667
Crane Cost Periods												
Hrs/month		176										
Hrs/Year		2112										
Weeks/Year		52										
Hrs/week		40.6										
Bare operation Rate			$85	$182	$213	$398	$511	$568	$710	$795	$795	$994
Standby Rate			$57	$136	$142	$265	$341	$379	$473	$530	$530	$663
OT Rate (for hrs over 40/wk)			$57	$121	$142	$265	$341	$379	$473	$530	$530	$663
60 hr week:		40.6										
Hrs/Week		60.0										
Weeks/yr		52.0										
Hrs/yr		3120.0										
O.T. Hrs/year		1008.0										
O.T. Hrs/week		19.4										
Bare operation Rate		100%	$3,461.54	$7,385	$8,654	$16,154	$20,769	$23,077	$28,846	$32,308	$32,308	$40,385
Standby Rate		0%	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
OT Rate (for hrs over 40/wk)		0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Rental Costs for 60 hr week			$3,462	$7,385	$8,654	$16,154	$20,769	$23,077	$28,846	$32,308	$32,308	$40,385
Hourly rate for 60 hr week			$58	$123	$144	$269	$346	$385	$481	$538	$538	$673
Total Yearly Costs for 60 hr week			$180,000	$384,000	$450,000	$840,000	$1,080,000	$1,200,000	$1,500,000	$1,680,000	$1,680,000	$2,100,000
Monthly Rate for 60 hr week			**$15,000**	**$32,000**	**$37,500**	**$70,000**	**$90,000**	**$100,000**	**$125,000**	**$140,000**	**$140,000**	**$175,000**

Assembly Work Pads

36'-0" x 83'-0" x 1'-0" - 4 req'd

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Concrete	444	CY	3	148	$40	$5,964	$80	$35,520	$41,484
Reinforcing steel	43,373	LBS	120	361	$40	$14,458		$0	$14,458
Concrete forming	238	SF	8	30	$40	$1,200	$3	$714	$1,914
Concrete Curing	3226	SF	250	13	$0	$0	$0.10	$323	$323
Concrete Finishing	3226	SF	70	46	$40	$1,840		$0	$1,840
Embedded Plates	3312	LBS	100	34	$40	$1,360	$1.25	$4,140	$5,500
Cradle Section	48	EA	1	48	$40	$1,920	$200	$9,600	$11,520
Center Cradle Section	24	EA	2	12	$40	$480	$15	$360	$840
Top & Bottom Templates	8	EA	0	0	$0	$0	$1,500	$12,000	$12,000
Screw Jacks	60	EA	0	0	$0	$0	$30	$1,800	$1,800
TOTALS				**692**		**$27,222**		**$64,457**	**$91,679**
Cost per Turbine				**14**		**$544**		**$1,289**	**$1,834**
Minimum	**-10%**			**12**		**$490**		**$1,160**	**$1,650**
Maximum	**15%**			**16**		**$626**		**$1,483**	**$2,109**

TABLE 6—Weight of Weld Metal
(lbs/ft of Joint)

Plate Thickness	Unlimited † Flat and Overhead 30° 1/16"	Unlimited † All Positions 45° 1/16"	Unlimited † Flat and Overhead 20° 1/8"	Unlimited † All Positions 45° 1/8"	Unlimited † Double V* / Max. 3/4" † Single V* 60° 1/8"	Unlimited † All Positions 45° 1/4"	Unlimited † Flat and Overhead 30° 3/8"	Unlimited † Flat and Overhead 20° 1/2"	Unlimited † Double Bevel* / Max. 3/4" † Single Bevel* 45° 1/8"	Unlimited † All Positions 45° 1/4"	Unlimited † Flat and Overhead 30° 3/8"
1/2"	.58	.65	.68	.67	.84	.89	.98	1.12	.74	1.00	1.01
3/4"	.90	1.40	1.27	1.35	1.70	1.60	1.60	1.80	1.52	1.87	1.65
1"	1.78	2.32	1.96	2.23	2.83	2.57	2.41	2.50	2.47	2.97	2.51
1 1/4"	2.40	3.65	2.60	3.32	4.27	3.67	3.35	3.30	3.70	4.35	3.45
1 1/2"	3.54	4.99	3.37	4.60	5.98	5.03	4.35	4.18	5.17	5.93	4.55
1 3/4"	4.65	6.70	4.20	6.06	7.93	6.55	5.55	5.17	6.87	7.80	5.80
2"	5.87	8.64	5.20	7.76	10.32	8.31	6.75	6.20	8.85	9.87	7.12
2 1/4"	7.20	10.80	6.23	9.35	12.90	10.23	8.15	7.32	11.10	12.20	8.60
2 1/2"	8.74	13.27	7.34	11.71	15.81	12.37	9.67	8.50	13.57	14.79	10.22
2 3/4"	10.40	15.90	8.60	14.00	19.00	14.70	11.37	9.85	16.30	17.75	12.00
3"	12.20	18.93	9.87	16.50	22.48	17.20	13.08	11.15	19.17	20.69	13.87

* All Positions

A.W.S. Highway and R.R. Bridge 1956—Prequalified Joints 9-5-57

Appendix O
Terrain Effects on Cranes

Assumptions:
1) Terrain effects on crane costs are being estimated by determining the cost impacts of multiple crane dissassembly and reassembly events.

2) Flat terrain with turbines aligned in a 2D by 10D grid represents ideal crane conditions in which the crane is assembled once during mobilization and dissassembled during demobilization. Relocation between turbines occurs without dissassembling the crane.

3) Sites with varying terrain, or those not aligned in a simplistic grid pose crane relocation challenges that result in more frequent disassembly of the crane to facilitate relocation.

4) The costs associated with crane disassembly/reassembly include crew labor, crane rental, and additional support cranes. The support cranes are necessary to assist the disassembly and reassembly process.

5) A conservative estimating approach is being applied that assumes the cranes need to be fully disassembled for relocation. It is being assumed that this approach will compensate for minor miscellaneous costs not contained in the labor and crane rental costs.

6) Since there is no obvious relationship between terrain and the number of crane disassemblies required, this analysis will determine the costs based on different values for the number of crane disassemblies per turbine.

From S1 - Detailed Crane Costs:

Crane Type	**4100 S1**	**4600 S4**	**4600 S5**	**what if**	**LTL-600**	**LTL-850**	**LTL-1000**	**LTL-1100**	**LTL-1100**	**LTL-1200**
Monthly Crane Costs during turbine assembly (60hr wk)	$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
Monthly crane costs other time	$15,000	$32,000	$37,500	$70,000	$90,000	$100,000	$125,000	$140,000	$140,000	$175,000
6 Month Rental Costs	$14,000	$29,867	$35,000	$65,333	$84,000	$93,333	$116,667	$130,667	$130,667	$163,333
9 Month Rental Costs	$13,500	$28,800	$33,750	$63,000	$81,000	$90,000	$112,500	$126,000	$126,000	$157,500
12 Month Rental Costs	$13,000	$27,733	$32,500	$60,667	$78,000	$86,667	$108,333	$121,333	$121,333	$151,667
7. Mobilization and Demobilization										
Crane Assembly and Disassembly Hours	24	48	48	80	160	192	360	360	360	480
Lampson Supervisor Hours	24	48	48	80	160	192	360	360	360	480
Lampson Supervisor Hourly Cost	$75	$75	$75	$75	$75	$75	$75	$75	$75	$75
Number of Iron Workers	4	4	4	4	6	6	8	8	8	10
Man Hours for Iron Workers	96	192	192	320	960	1152	2880	2880	2880	4800
Iron Worker Hourly Cost	$65	$65	$65	$65	$65	$65	$65	$65	$65	$65
Crane Rental Period (Months) During Assembly	0.1	0.3	0.3	0.5	0.9	1.1	2.0	2.0	2.0	2.7
Crane Rental Cost	$2,045	$8,727	$10,227	$31,818	$81,818	$109,091	$255,682	$286,364	$286,364	$477,273
Total Labor Costs	$8,040	$16,080	$16,080	$26,800	$74,400	$89,280	$214,200	$214,200	$214,200	$348,000
Truck Crane 1 Hourly Cost	$185	$185	$185	$185	$185	$185	$185	$185	$185	$185
Truck Crane 2 Hourly Cost	$325	$325	$325	$325	$325	$350	$350	$350	$350	$400
Truck Crane 3 Hourly Costs	$0	$0	$0	$0	$0	$0	$0	$185	$185	$185
Total Truck Crane Costs	$12,240	$24,480	$24,480	$40,800	$81,600	$102,720	$192,600	$259,200	$259,200	$369,600
Total Transportation Freight in/out	$40,000	$60,000	$70,000	$80,000	$120,000	$120,000	$200,000	$220,000	$220,000	$220,000
Transport Days in/out	6	10	10	10	14	14	20	20	24	24
Transport Hours in/out	48	80	80	80	112	112	160	160	192	192
Crane Rental During Transport	$4,091	$14,545	$17,045	$31,818	$57,273	$63,636	$113,636	$127,273	$152,727	$190,909
SubTotal	$66,416	$123,833	$137,833	$211,236	$415,091	$484,727	$976,118	$1,107,036	$1,132,491	$1,605,782
Mob/Demob Costs/Turbine	$1,328	$2,477	$2,757	$4,225	$8,302	$9,695	$19,522	$22,141	$22,650	$32,116

The existing crane costs include one crane assembly/disassembly as part of mobilization and demobilization. These costs have been specifically shown below:

	4100 S1	4600 S4	4600 S5	what if	LTL-600	LTL-850	LTL-1000	LTL-1100	LTL-1100	LTL-1200
Total Labor Costs	$8,040	$8,040	$8,040	$8,040	$8,040	$8,040	$8,040	$8,040	$8,040	$8,040
Crane Rental Cost	$2,045	$8,727	$10,227	$31,818	$81,818	$109,091	$255,682	$286,364	$286,364	$477,273
Total Truck Crane Costs	$12,240	$24,480	$24,480	$40,800	$81,600	$102,720	$192,600	$259,200	$259,200	$369,600
Subtotal:	$22,325	$41,247	$42,747	$80,658	$171,458	$219,851	$456,322	$553,604	$553,604	$854,913
Subtotal per Turbine:	$447	$825	$855	$1,613	$3,429	$4,397	$9,126	$11,072	$11,072	$17,098

Number of additional disassembly and reassembly events (during construction of a 50 turbine facility):	Additional costs per turbine for varying frequency of crane disassembly/reassembly									
1	$447	$825	$855	$1,613	$3,429	$4,397	$9,126	$11,072	$11,072	$17,098
4	$1,786	$3,300	$3,420	$6,453	$13,717	$17,588	$36,506	$44,288	$44,288	$68,393
9	$4,019	$7,425	$7,695	$14,518	$30,862	$39,573	$82,138	$99,649	$99,649	$153,884
24	$10,716	$19,799	$20,519	$38,716	$82,300	$105,528	$219,034	$265,730	$265,730	$410,358

Calculating the impact of additional crane disassembly/reassembly events on the total crane costs/kW is presented below. Since the existing costs/kW include one crane assembly/disassembly, only the costs associated with ADDITIONAL events are being added.

From S1 Summarized Crane Costs:

Turbine Class:	750		1,500			2,500	3500		5000	
Rotor Diameter:	50	50	66	66	66	85	100	100	120	120
Crane Type:	**4100 S1**	**4600 S4**	**4600 S5**	**what if**	**LTL-600**	**LTL-850**	**LTL-1000**	**LTL-1100**	**LTL-1100**	**LTL-1200**
Crane Crew Assembly Labor Costs/Turbine	$1,365	$1,365	$2,457	$2,457	$3,686	$7,332	$10,296	$10,296	$17,550	$17,550
Crane Crew Relocation Labor Costs/Turbine	$780	$780	$780	$1,040	$1,560	$2,730	$4,095	$4,875	$4,875	$6,435
Crane Rental Costs During Assembly and Relocation/Turbine	$952	$2,031	$3,591	$7,242	$9,312	$18,523	$31,933	$37,703	$53,667	$71,750
Meals and Lodging/Turbine	$248	$248	$374	$404	$605	$1,161	$1,661	$1,751	$2,588	$2,768
Fuel Cost/Turbine	$91	$103	$156	$168	$437	$839	$1,292	$1,362	$2,013	$2,306
Cribbing Costs/Turbine	$131	$190	$595	$595	$808	$538	$808	$943	$943	$943
Mob/Demob Costs/Turbine	$1,328	$2,477	$2,757	$4,225	$8,302	$9,695	$19,522	$22,141	$22,650	$32,116
Total Crane and Crew Costs/Turbine	$4,894	$7,193	$10,709	$16,131	$24,709	$40,817	$69,606	$79,069	$104,284	$133,867
Total Crane Costs (50 Turbines)	$244,713	$359,652	$535,456	$806,533	$1,235,437	$2,040,831	$3,480,278	$3,953,465	$5,214,199	$6,693,344
Costs/kW	$5.67	$8.33	$7.11	$10.72	$16.41	$16.35	$20.14	$22.88	$20.96	$26.90

Number of Turbines Assembled per Crane Assembly/Disassembly	Adjusted Crane Costs per kW based on additional crane disassembly and reassembly events									
50	$5.67	$8.33	$7.11	$10.72	$16.41	$16.35	$20.14	$22.88	$20.96	$26.90
25	$6.18	$9.28	$7.68	$11.79	$18.69	$18.11	$22.78	$26.08	$23.18	$30.34
10	$7.73	$12.15	$9.39	$15.00	$25.53	$23.39	$30.71	$35.70	$29.86	$40.64
5	$10.32	$16.92	$12.23	$20.36	$36.92	$32.20	$43.91	$51.72	$40.98	$57.82
2	$18.07	$31.24	$20.74	$36.44	$71.09	$58.61	$83.52	$99.78	$74.36	$109.36

Number of Turbines Assembled per Crane Assembly/Disassembly	4600 S4	LTL-600	LTL-850	LTL-1100	LTL-1200
	750	**1500**	**2500**	**3500**	**5000**
50	$8.33	$16.41	$16.35	$22.88	$26.90
25	$9.28	$18.69	$18.11	$26.08	$30.34
10	$12.15	$25.53	$23.39	$35.70	$40.64
5	$16.92	$36.92	$32.20	$51.72	$57.82
2	$31.24	$71.09	$58.61	$99.78	$109.36

Number of Turbines Assembled per Crane Assembly/Disassembly	Number of Normal Relocations	Number of Extra Crane Disassemblies
50	50	0
25	49	1
10	46	4
5	41	9
2	26	24

Crane Type	**4100 S1**	**4600 S4**	**4600 S5**	**what if**	**LTL-600**	LTL-850	LTL-1000	LTL-1100	LTL-1100	LTL-1200
Crane Assembly Rate Days/Turbine	1.05	1.05	1.89	1.89	1.89	3.76	5.28	5.28	9	9
Estimated Relocation Hours/Turbine	6	6	6	8	8	14	21	25	25	33
Crane Assembly and Disassembly Hours	24	48	48	80	160	192	360	360	360	480

Number of Turbines:	50
Hours per day	10

Combined Normal Crane Relocation Time AND Extra Crane Disassembly Time (Days/Turbine)

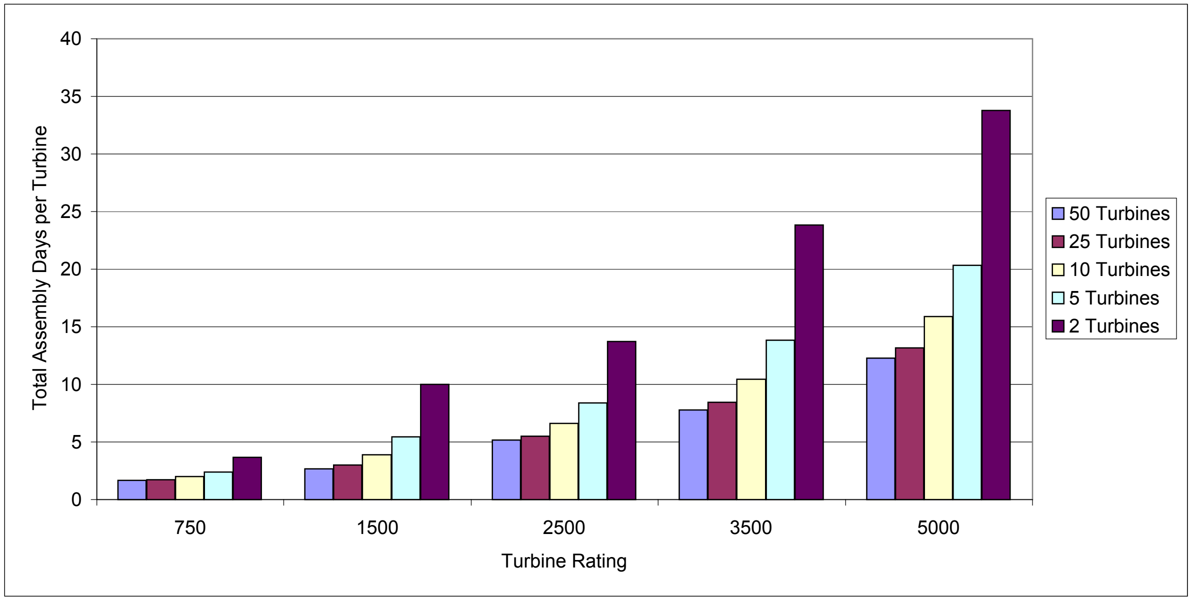
Number of Turbines Assembled per Crane Assembly/Disassembly	4100 S1	4600 S4	4600 S5	what if	LTL-600	LTL-850	LTL-1000	LTL-1100	LTL-1100	LTL-1200
50	0.6	0.6	0.6	0.8	0.8	1.4	2.1	2.5	2.5	3.3
25	0.6	0.7	0.7	0.9	1.1	1.8	2.8	3.2	3.2	4.2
10	0.7	0.9	0.9	1.4	2.0	2.8	4.8	5.2	5.2	6.9
5	0.9	1.4	1.4	2.1	3.5	4.6	8.2	8.5	8.5	11.3
2	1.5	2.6	2.6	4.3	8.1	9.9	18.4	18.6	18.6	24.8

Total Number of Assembly Days per Turbine

Number of Turbines Assembled per Crane Assembly/Disassembly	**4100 S1**	**4600 S4**	**4600 S5**	**what if**	**LTL-600**	LTL-850	LTL-1000	LTL-1100	LTL-1100	LTL-1200
50	1.7	1.7	2.5	2.7	2.7	5.2	7.4	7.8	11.5	12.3
25	1.7	1.7	2.6	2.8	3.0	5.5	8.1	8.5	12.2	13.2
10	1.8	2.0	2.8	3.3	3.9	6.6	10.1	10.5	14.2	15.9
5	2.0	2.4	3.2	4.0	5.4	8.4	13.5	13.8	17.5	20.3
2	2.5	3.7	4.5	6.1	10.0	13.7	23.7	23.9	27.6	33.8

Number of Turbines Assembled per Crane Assembly/Disassembly	750	1500	2500	3500	5000
50	1.7	2.7	5.2	7.8	12.3
25	1.7	3.0	5.5	8.5	13.2
10	2.0	3.9	6.6	10.5	15.9
5	2.4	5.4	8.4	13.8	20.3
2	3.7	10.0	13.7	23.9	33.8

Number of Turbines Assembled per Crane Assembly/Disassembly	750	1500	2500	3500	5000
50	3	4	9	13	21
25	3	5	9	14	22
10	3	7	11	17	26
5	4	9	14	23	34
2	6	17	23	40	56

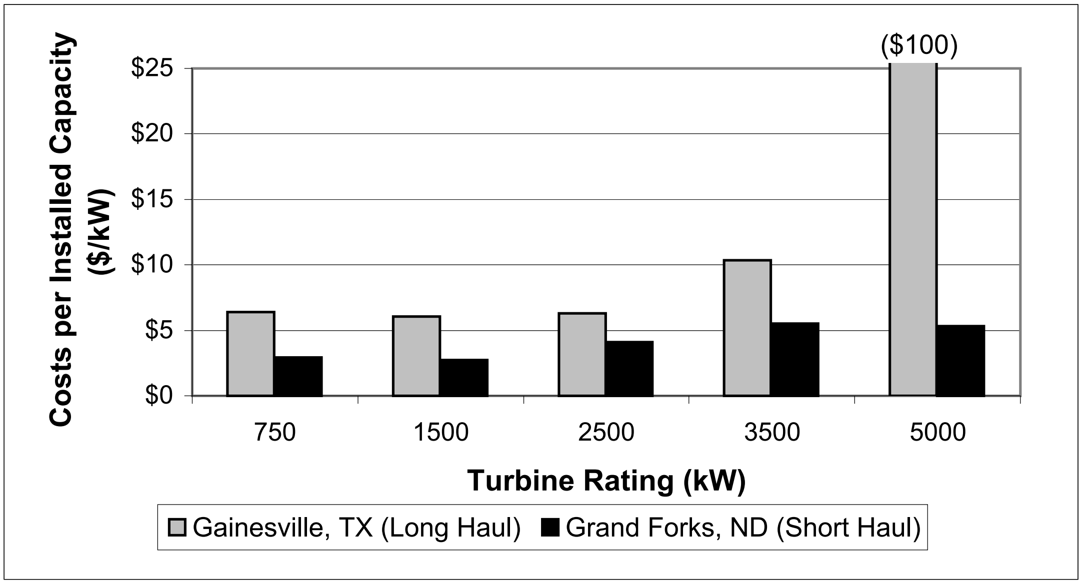


40
35
30
25
20
15
10
5
0
Total Assembly Days per Turbine
750
1500
2500
3500
5000
Turbine Rating
50 Turbines
25 Turbines
10 Turbines
5 Turbines
2 Turbines

Appendix P
Report Figures and Road-Width Analysis

Data from Scenario 1 - Costs per kW page C-1.

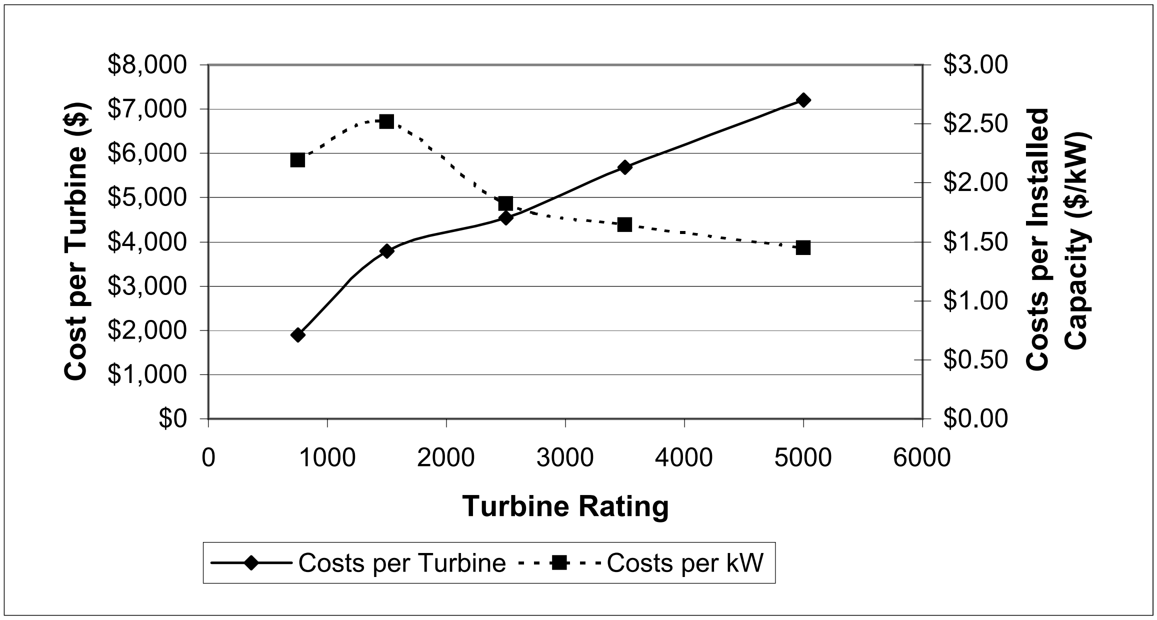
		750	1500	2500	3500	5000
Gainesville, TX	South Dakota	$6.40	$6.06	$6.30	$10.37	$100.41
Grand Forks, ND	South Dakota	$2.91	$2.76	$4.10	$5.51	$5.31



Data From Page D-2 "Hubs via Trucks"

From Chicago, IL

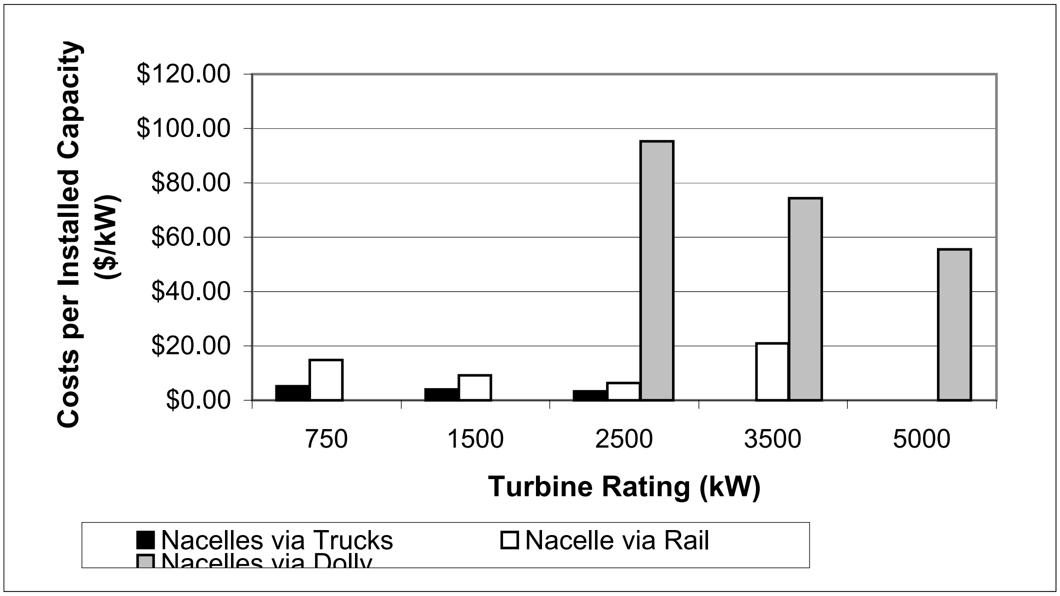
Turbine Rating (kW)	750	1500	2500	3500	5000
Costs per Turbine	$1,895	$3,790	$4,548	$5,685	$7,201
Costs per kW	$2.19	$2.52	$1.82	$1.65	$1.45



Data from Scenario 1 - Costs per kW page C-1 and C-2

		750	1500	2500	3500	5000
Chicago, IL	South Dakota	$5.26	$4.03	$3.34		
Chicago, IL	South Dakota	$14.85	$9.19	$6.37	$20.92	
Chicago, IL	South Dakota			$95.28	$74.33	$55.42

Key:
Trucks
Rail
Dolly



Data from Scenario 1 - Costs per kW page C-1 and C-2

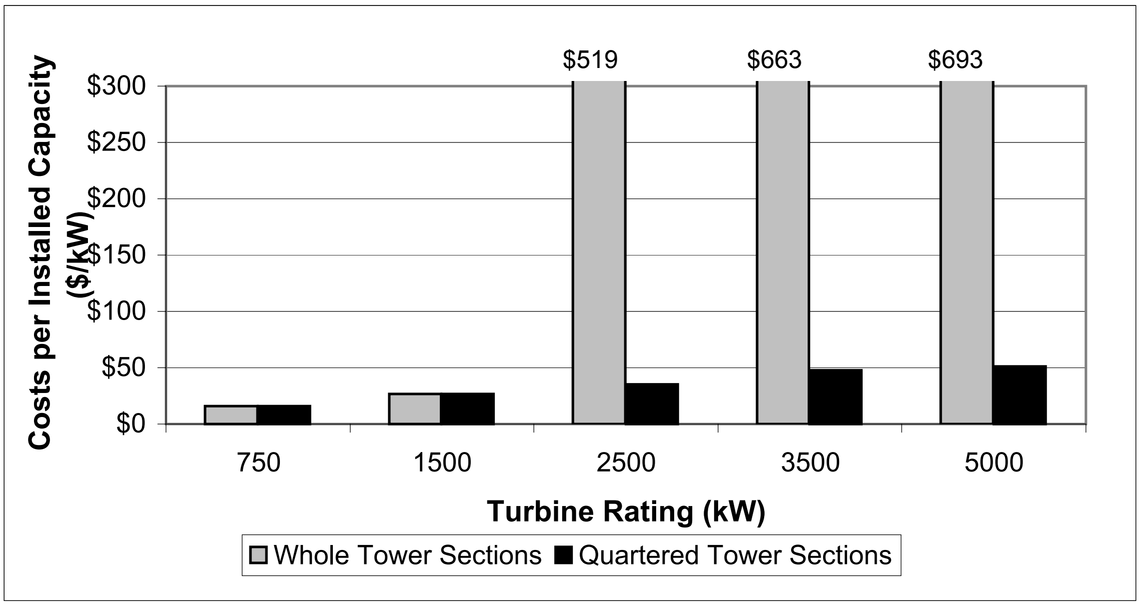
Scenario 1

		750	1500	2500	3500	5000	
Shreveport, LA	South Dakota	$15.89	$26.61	$8.77	$3.40	$0.00	Truck
Shreveport, LA	Port of Houston	$0.00	$0.00	$194.65	$234.39	$227.88	Dolly
Port of Houston	Sioux City, IA	$0.00	$0.00	$120.15	$190.44	$236.19	Barge
Sioux City, IA	South Dakota	$0.00	$0.00	$195.25	$235.12	$228.58	Dolly
	Total	**$16**	**$27**	**$519**	**$663**	**$693**	

Data from Scenario 2 - Costs per kW page C-3 and C-4

Scenario 2

Shreveport, LA	South Dakota	$15.89	$26.61	$35.29	$47.84	$51.04	Truck



Data from Scenario 1 - Costs per kW page C-1 and C-2

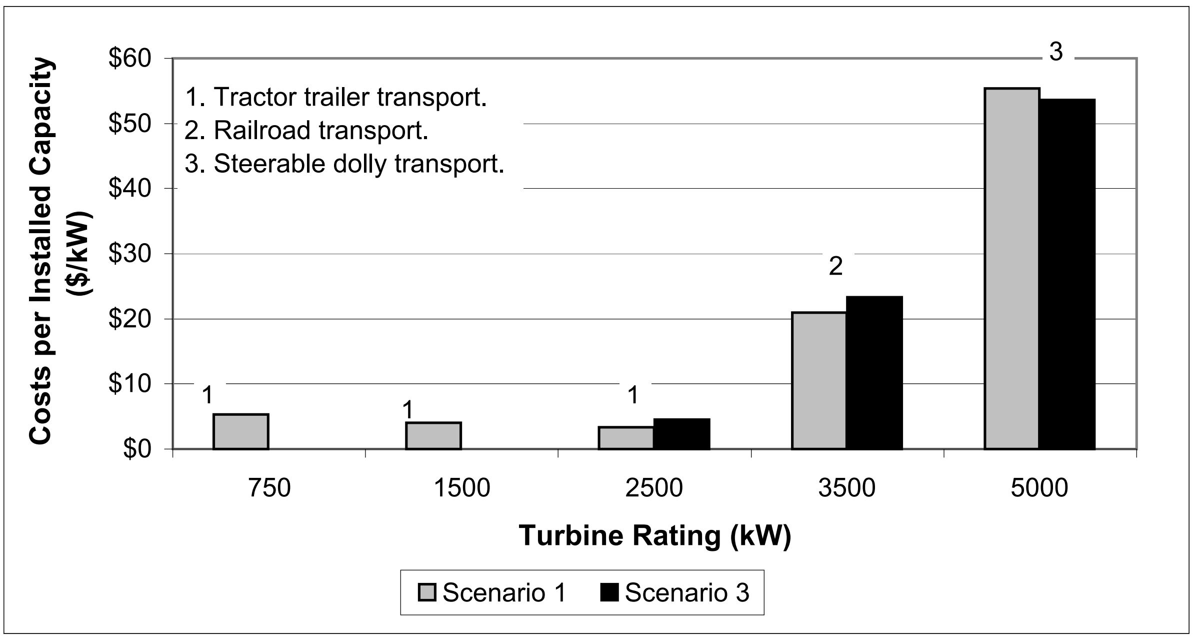
		750	1500	2500	3500	5000	
Scenario 1							
Chicago, IL	South Dakota	$5.26	$4.03	$3.34	$0.00	$0.00	Truck
		$0.00	$0.00	$95.28	$74.33	$55.42	Dolly
		$14.85	$9.19	$6.37	$20.92	$0.00	Rail

Data from Scenario 3 - Costs per kW page C-5 and C-6

= generator and gear box costs

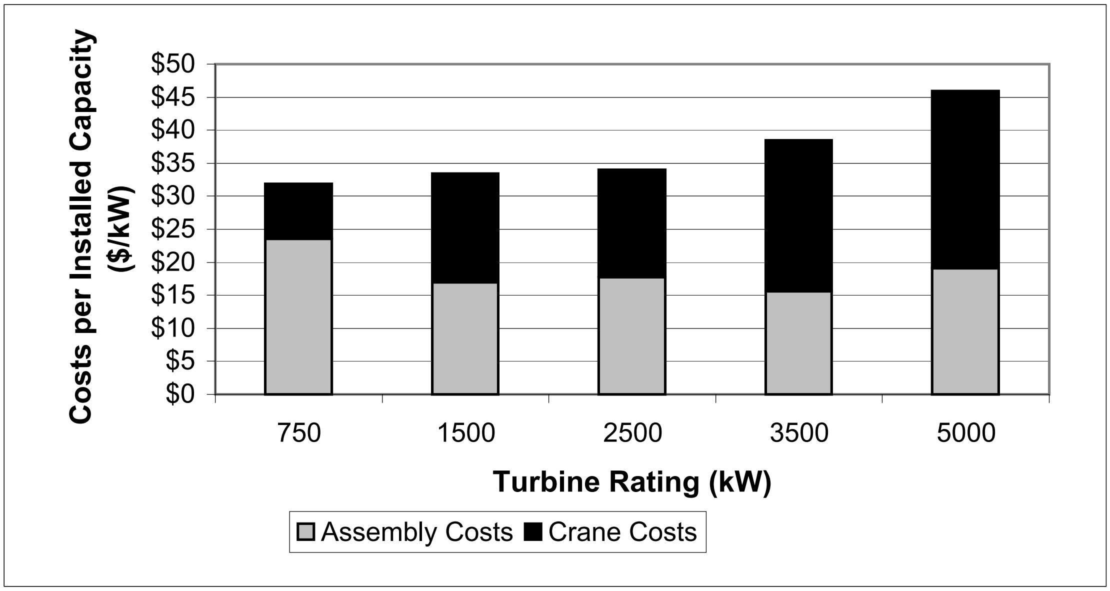
		750	1500	2500	3500	5000	
Scenario 3							
Chicago, IL	South Dakota	$5.26	$4.03	$4.55	$2.85	$1.98	Truck
		$0.00	$0.00	$0.00	$68.84	$51.61	Dolly
		$14.28	$8.89	$6.04	$20.43	$0.00	Rail
		$0.00	$0.00	$0.00	$71.69	$53.60	Adjusted Dolly
		$14.28	$8.89	$6.04	$23.29	$0.00	Adjusted Rail

Lowest Cost Options	750	1500	2500	3500	5000
Scenario 1	$5.26	$4.03	$3.34	$20.92	$55.42
Scenario 3	$0.00	$0.00	$4.55	$23.29	$53.60



See 'Cost per kW' page B-3 and B-4

	750	1500	2500	3500	5000
Assembly	$23.55	$16.98	$17.70	$15.60	$19.05
Crane	$8.33	$16.41	$16.35	$22.88	$26.90



Source: Chicago Bridge and Iron Co.

Capacity group	CountOfCapacity
100	3
200	39
300	39
400	18
500	18
600	12
700	5
800	9
900	3
1000	8
1200	3
1400	2
1500	1
1600	4
1800	1
2000	2
2200	1
2800	1
3800	1

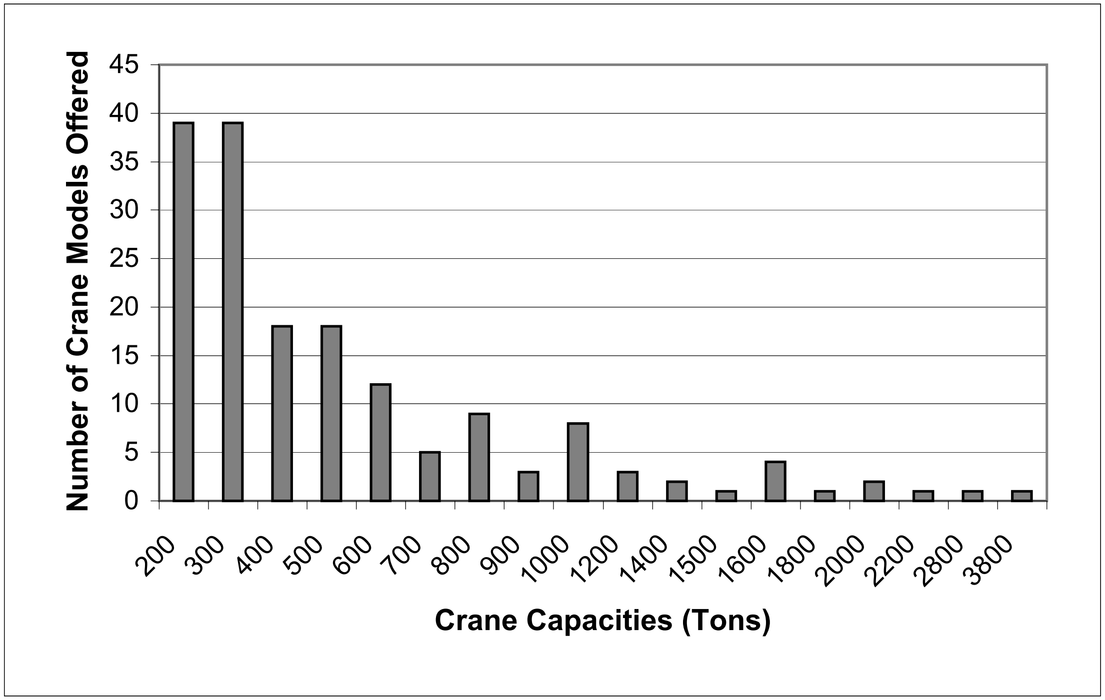
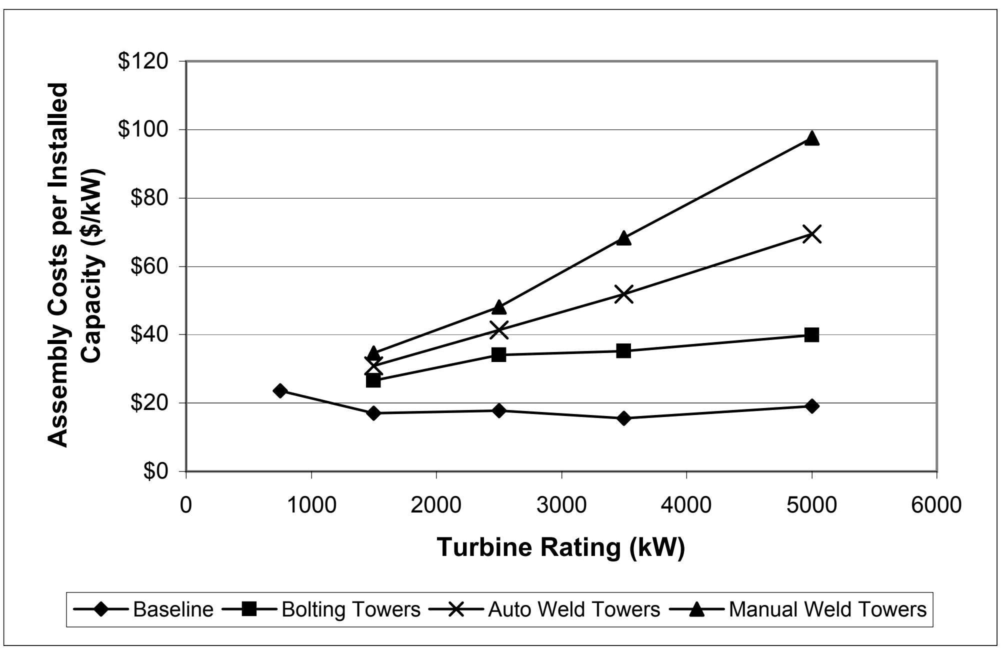


Figure 4-12

See 'Cost per kW' data on pages B-3 and B-4

	750	1500	2500	3500	5000	
Assembly	$23.55	$16.98	$17.70	$15.60	$19.05	S1
Crane	$8.33	$16.41	$16.35	$22.88	$26.90	S1
	$31.88	**$33.39**	**$34.04**	**$38.48**	**$45.95**	
Assembly	$23.55	$26.49	$34.00	$35.12	$39.85	S2 Bolt
Crane	$8.33	$19.00	$19.71	$28.32	$33.23	S2 Bolt
	$31.88	**$45.49**	**$53.72**	**$63.45**	**$73.08**	
Assembly	$23.55	$34.57	$48.16	$68.36	$97.53	S2 Man
Crane	$8.33	$21.77	$24.99	$43.15	$60.11	S2 Man
	$31.88	**$56.35**	**$73.14**	**$111.50**	**$157.64**	
Assembly	$23.55	$30.89	$41.30	$51.78	$69.45	S2 Auto
Crane	$8.33	$20.64	$22.88	$36.45	$47.89	S2 Auto
	$31.88	**$51.53**	**$64.18**	**$88.24**	**$117.34**	
Assembly	$23.55	$26.49	$35.29	$36.53	$41.12	S3
Crane	$8.33	$19.00	$21.23	$30.24	$35.20	S3
	$31.88	**$45.49**	**$56.52**	**$66.77**	**$76.32**	



See 'Cost per kW' data on pages B-3 and B-4

	750	1500	2500	3500	5000	
Assembly	$23.55	$16.98	$17.70	$15.60	$19.05	S1
Crane	$8.33	$16.41	$16.35	$22.88	$26.90	S1
	$31.88	**$33.39**	**$34.04**	**$38.48**	**$45.95**	**Combined**
Assembly	$23.55	$26.49	$34.00	$35.12	$39.85	S2 Bolt
Crane	$8.33	$19.00	$19.71	$28.32	$33.23	S2 Bolt
	$31.88	**$45.49**	**$53.72**	**$63.45**	**$73.08**	**Combined**
Assembly	$23.55	$34.57	$48.16	$68.36	$97.53	S2 Man
Crane	$8.33	$21.77	$24.99	$43.15	$60.11	S2 Man
	$31.88	**$56.35**	**$73.14**	**$111.50**	**$157.64**	**Combined**
Assembly	$23.55	$30.89	$41.30	$51.78	$69.45	S2 Auto
Crane	$8.33	$20.64	$22.88	$36.45	$47.89	S2 Auto
	$31.88	**$51.53**	**$64.18**	**$88.24**	**$117.34**	**Combined**
Assembly	$23.55	$26.49	$35.29	$36.53	$41.12	S3
Crane	$8.33	$19.00	$21.23	$30.24	$35.20	S3
	$31.88	**$45.49**	**$56.52**	**$66.77**	**$76.32**	**Combined**

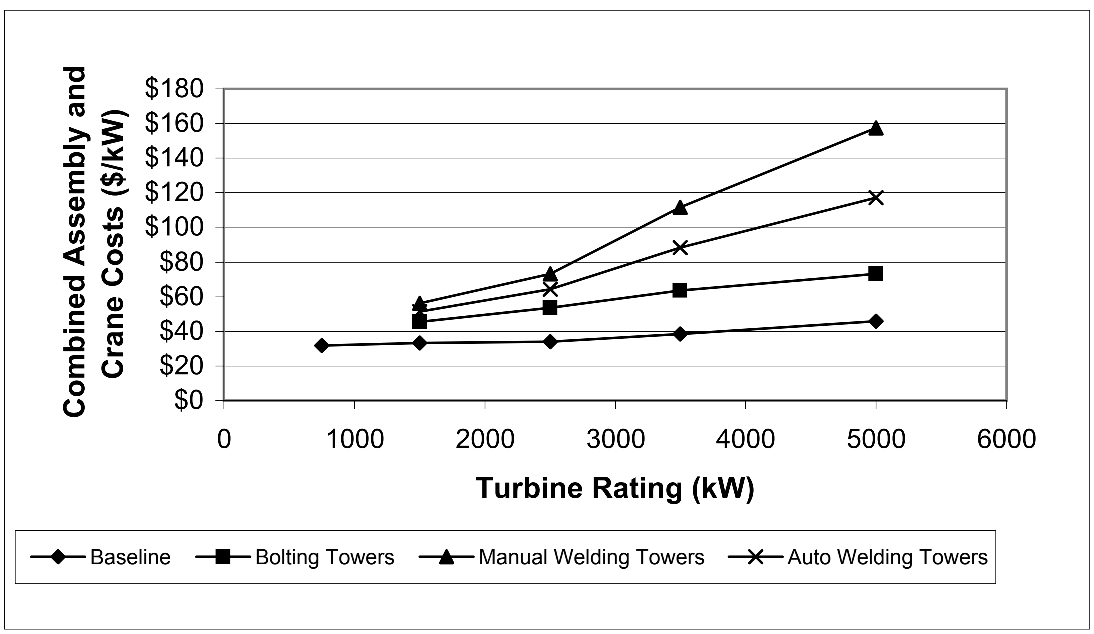
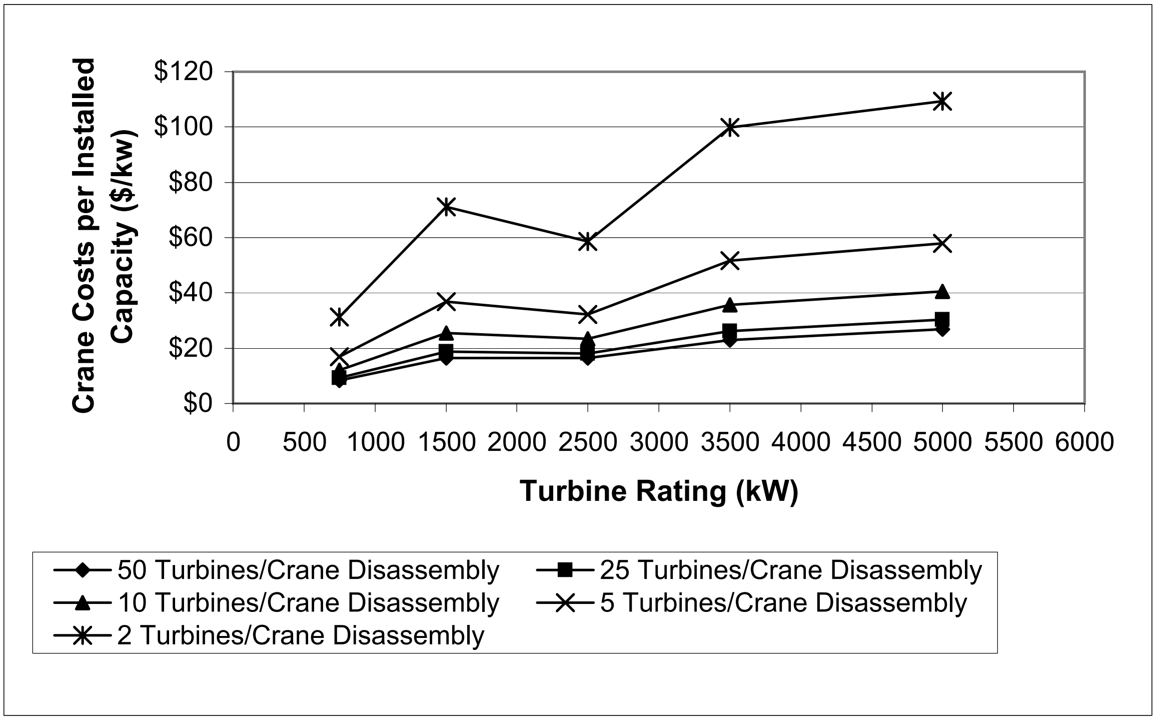


Figure 4-14

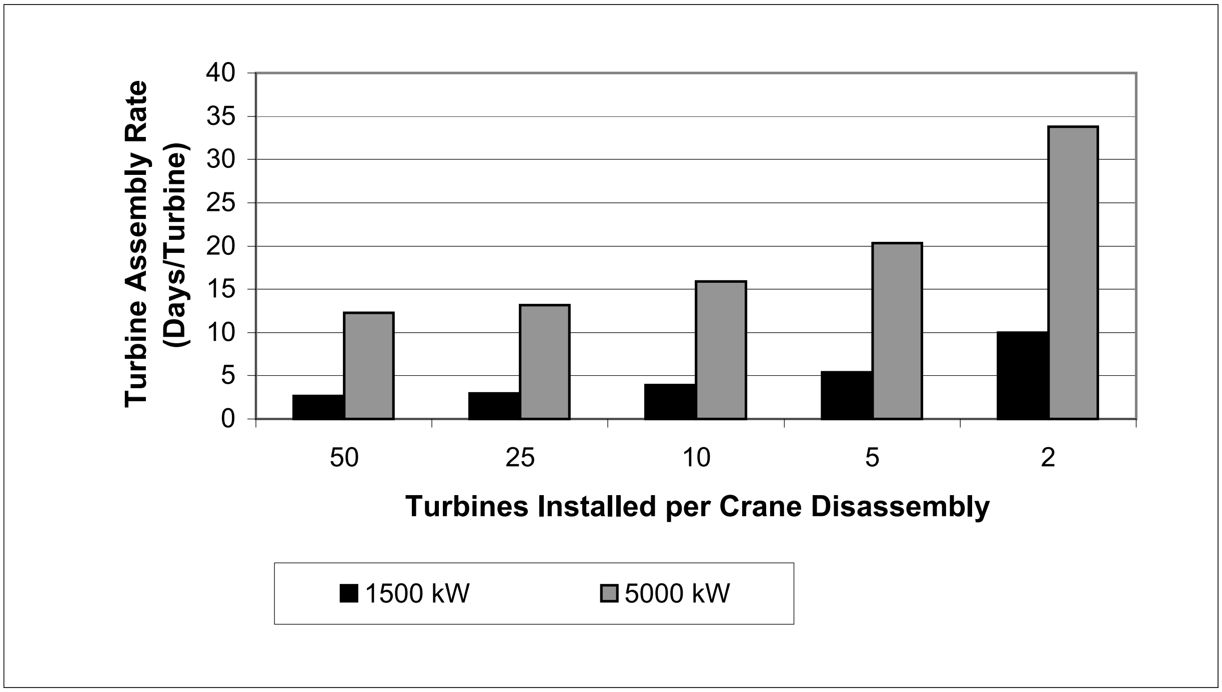
Data From Appendix O

Number of Turbines Assembled per Crane Assembly/Disassembly	4600 S4 750	LTL-600 1500	LTL-850 2500	LTL-1100 3500	LTL-1200 5000
50	$8.33	$16.41	$16.35	$22.88	$26.90
25	$9.28	$18.69	$18.11	$26.08	$30.34
10	$12.15	$25.53	$23.39	$35.70	$40.64
5	$16.92	$36.92	$32.20	$51.72	$57.82
2	$31.24	$71.09	$58.61	$99.78	$109.36



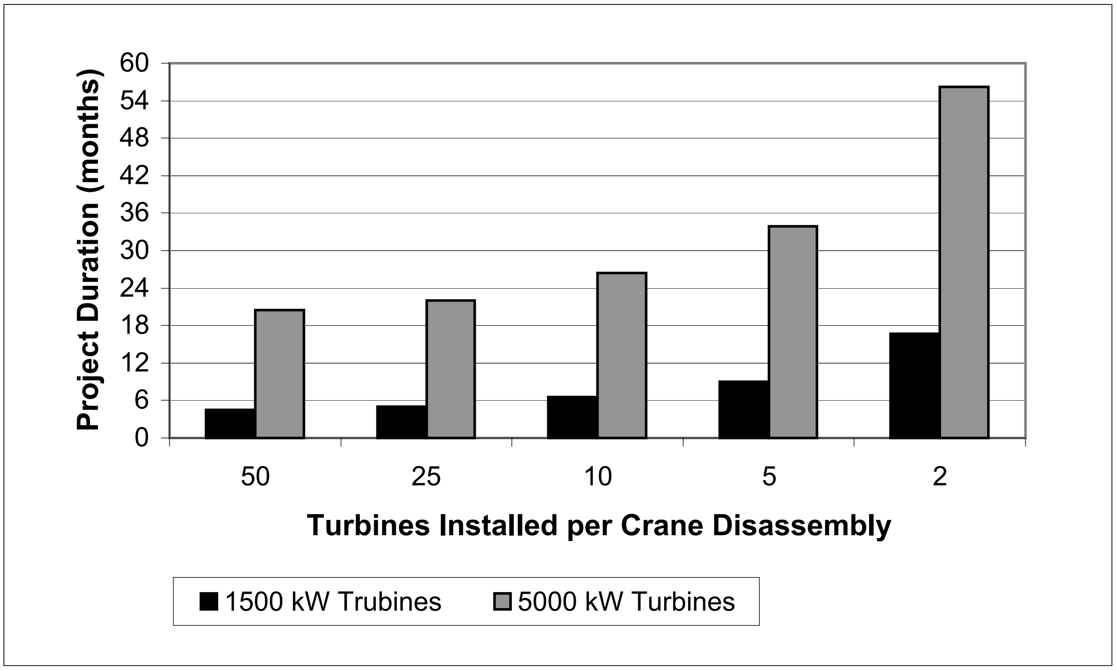
Data From Appendix O

Number of Turbines Assembled per Crane Assembly/Disassembly	**750**	**1500**	**2500**	**3500**	**5000**
50	1.65	2.69	5.16	7.78	12.3
25	1.734	2.994	5.516	8.45	13.194
10	1.986	3.906	6.584	10.46	15.876
5	2.406	5.426	8.364	13.81	20.346
2	3.666	9.986	13.704	23.86	33.756



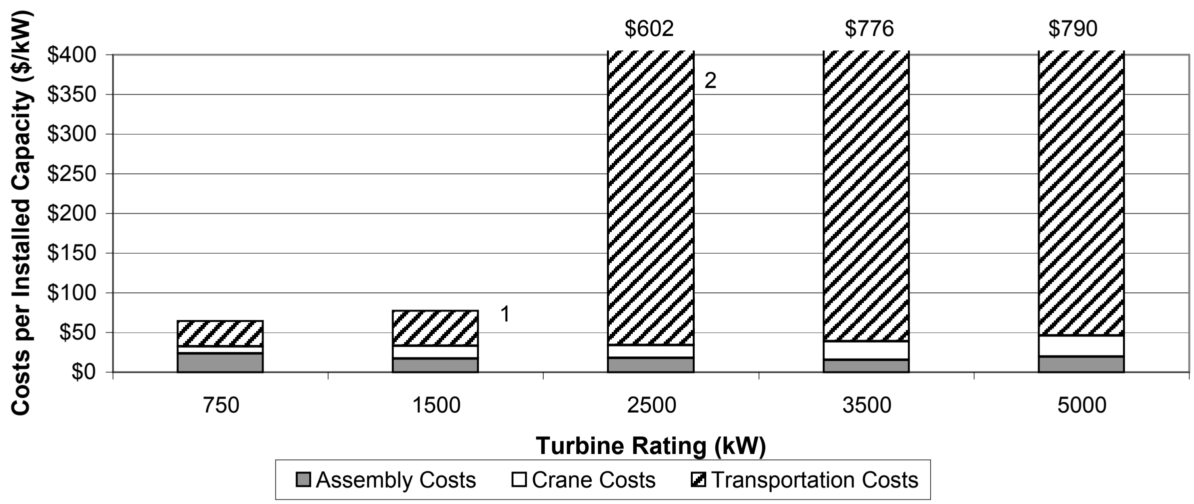
Data From Appendix O

Number of Turbines	**750**	**1500**	**2500**	**3500**	**5000**
50	3	4	9	13	21
25	3	5	9	14	22
10	3	7	11	17	26
5	4	9	14	23	34
2	6	17	23	40	56



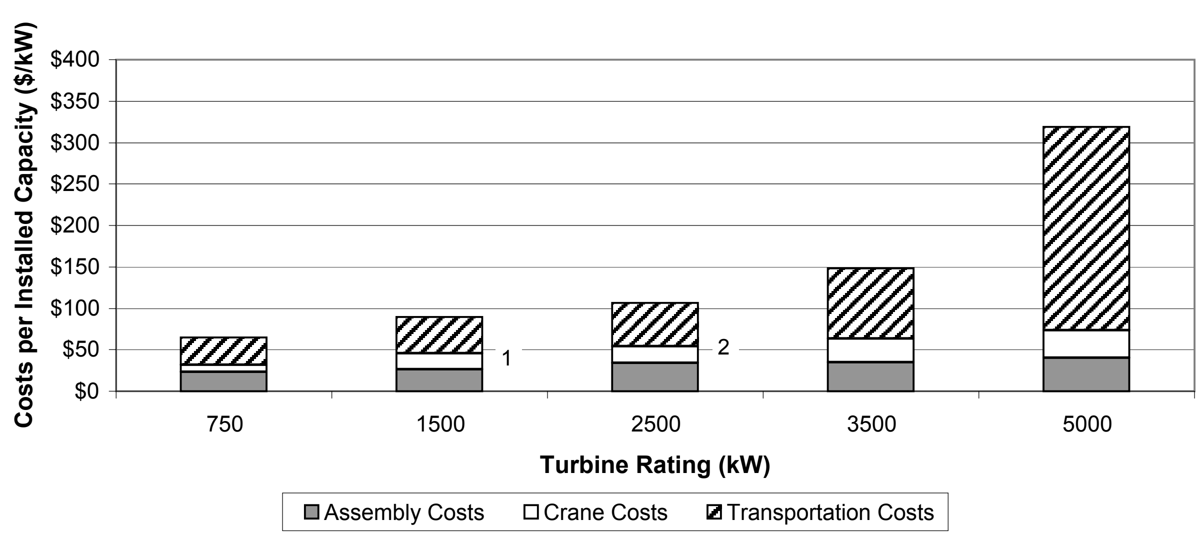
Mid-range (typical or average) Costs by Scenario from Appendix B

	750	1500	2500	3500	5000	
Turbine (kW)	**750**	**1500**	**2500**	**3500**	**5000**	
Rotor Dia (m)	**50**	**66**	**85**	**100**	**120**	
Scenario 1	$32.71	$43.99	$567.92	$737.94	$923.68	Transportation (Long Haul)
	$23.55	$16.98	$17.70	$15.60	$19.05	Assembly
	$8.33	$16.41	$16.35	$22.88	$26.90	Cranes (Optimum - no terrain effects)
	$65	**$77**	**$602**	**$776**	**$970**	
Scenario 2	$32.71	$43.99	$53.02	$85.16	$246.13	Transportation (Long Haul)
(Bolted Towers)	$23.55	$26.49	$34.00	$35.12	$39.85	Assembly
	$8.33	$19.00	$19.71	$28.32	$33.23	Cranes (Optimum - no terrain effects)
	$65	**$89**	**$107**	**$149**	**$319**	
Scenario 3	$32.71	$43.99	$54.78	$89.79	$242.44	Transportation (Long Haul)
(Bolted Towers)	$23.55	$26.49	$35.29	$36.53	$41.12	Assembly
	$8.33	$19.00	$21.23	$30.24	$35.20	Cranes (Optimum - no terrain effects)
	$65	**$89**	**$111**	**$157**	**$319**	



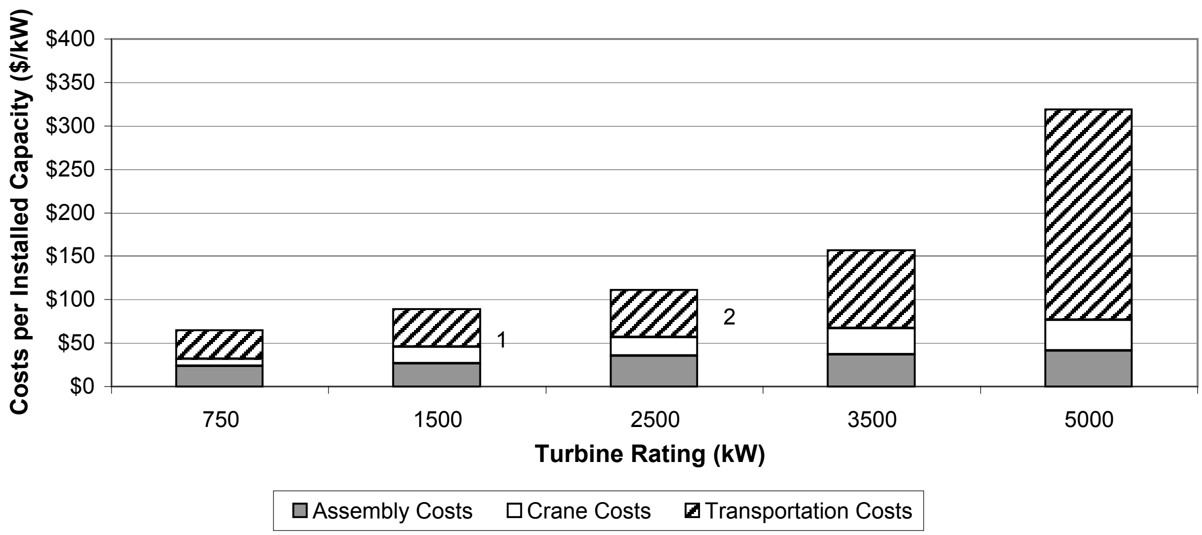
1 - Transportation costs assume tower base diameter is less than 4.4 m (1500 kW)

2 - Transporation costs assume 2500-kW nacelle is less than 84,000 kg.



1 - Transportation costs assume tower base diameter is less than 4.4m (1500 kW only)

2 - Transportation costs assume 2500 kW nacelle is less than 84,000 kg



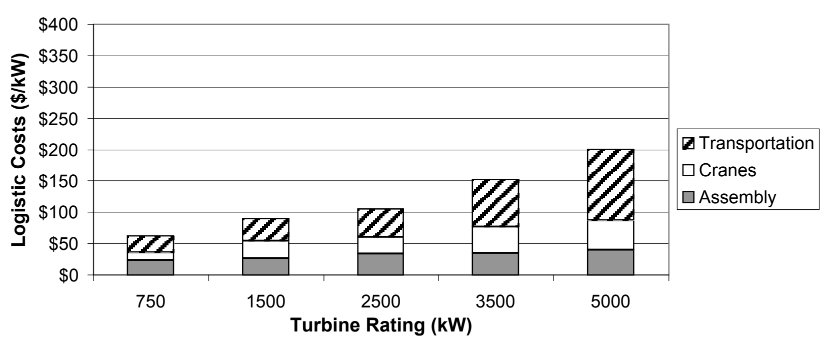
1 - Transportation costs assume tower base diameter is less than 4.4m (1500 kW).

2 - Transportation costs assume 2500 kW nacelle is less than 84,000 kg.

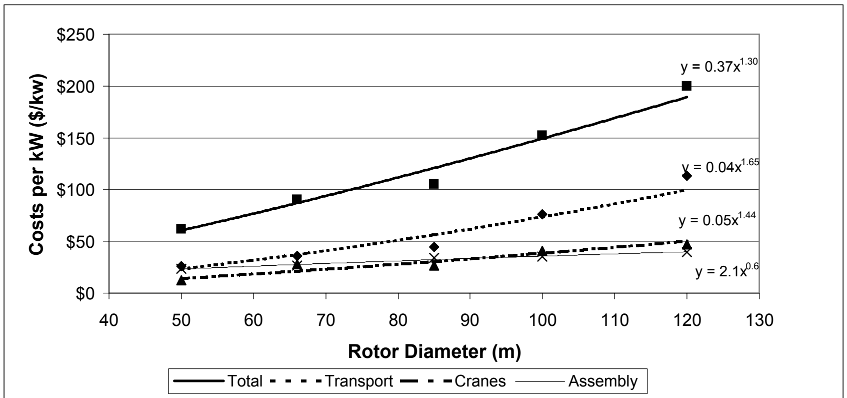
Detailed Analysis of Scenario 2 with respect to South Dakota project site.

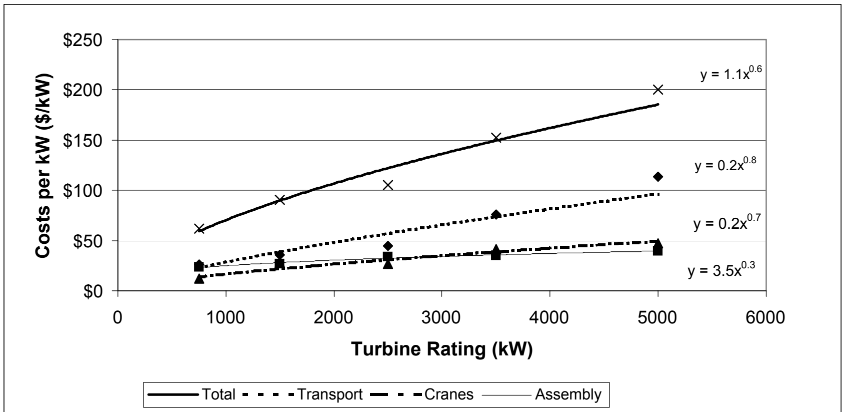
1 Mid-range (typical or average) costs are utilized.
2 Short-haul transport costs are used for the 5 MW blade since long-haul shipping via barge is highly unlikely.
3 Terrain effects are accounted for in crane costs by assuming 10 turbines are assembled per crane disassembly.

Rating (kW)	**750**	**1500**	**2500**	**3500**	**5000**	
Rotor Ria (m)	**50**	**66**	**85**	**100**	**120**	
Scenario 2	$32.71	$43.99	$53.02	$85.16	$246.13	Long-Haul Transport w/ 5 MW Blade Barged.
	$32.71	$43.99	$53.02	$85.16	$113.21	Long-Haul Transport EXCEPT Short Haul for the 5MW Turbine.
	$26.25	$35.91	$44.55	$75.91	$113.21	Short-Haul Transportation Costs From Scenario 2.
	$23.55	$26.49	$34.00	$35.12	$39.85	Assembly - S2 Avg Bolted connections
	$12.15	$25.53	$23.39	$35.70	$40.64	Assembly Crane Costs - 10 Turbines/Disassembly
		$2.58	$3.36	$5.44	$6.33	Tower Fabrication Crane Costs - Scenario 2 crane for bolted tower fabrication.
	$12.15	$28.11	$26.76	$41.14	$46.97	Total Crane Costs Including Terrain Effects (10 Turbines/Disassembly)
	$61.94	**$90.50**	**$105.31**	**$152.17**	**$200.03**	**Total Logictics Costs**



1. Assembly based on field fabrication of towers with bolted connections.
2. Crane costs based on 10 turbines assembled for each crane tear-down plus one crane for tower fabrication.
3. Transportation based on long haul estimates with quartered tower sections except 5 MW blades (short haul by truck).





Appendix Q
Mortenson Estimates

GLOBAL ENERGY CONCEPTS, LLC.

MEGA - WATT SCALE WIND TURBINE CONSTRUCTION

REVISED JULY 12, 2000

	750 KW			1500 KW			2500 KW			3500 KW			5000 KW		
Activity Description	MHRS	Labor Cost (Loaded)	Equip. & Material Cost	MHRS	Labor Cost (Loaded)	Equip. & Material Cost	MHRS	Labor Cost (Loaded)	Equip. & Material Cost	MHRS	Labor Cost (Loaded)	Equip. & Material Cost	MHRS	Labor Cost (Loaded)	Equip. & Material Cost
Receive/Uncrate Nacelle,Blades, Rotors & Towers	54	$2,176		62	$2,499		75	$3,023		96	$3,869		142	5,723	
Rig & Set Tower Sections	64	$2,580		132	$5,320		243	$9,792		354	$14,265		619	24,810	
Grout & Torque Bases	37	$1,492	$450	40	$1,612	$850	59	$2,377	$950	70	$2,822	$1,120	87	3,506	1,650
Assemble Rotors/Blades & Nacelle	43	$1,733	$150	50	$2,015	$250	74	$2,982	$500	86	$3,465	$700	124	4,998	1,000
Rig & Set Nacelle & Blades	41	$2,248		57	$2,317		133	$6,488		174	$8,549		280	13,370	
Install Safety Equipment	9	$363		12	$484		20	$806		24	$968		36	1,450	
General Conditions		$2,172	$5,713		$2,172	$5,713		$2,459	$10,789		$2,459	$10,789		8,728	20,941
Margin @ 10%		$1,276	$631		$1,642	$681		$2,793	$1,224		$3,640	$1,261		$6,259	$2,359
Subtotal Per Turbine	248	$14,040	$6,944	353	$18,061	$7,494	604	$30,720	$13,463	804	$40,037	$13,870	1288	$68,844	$25,950
Project Total (50 turbines)	12,400	$702,020	$347,215	17,650	$903,045	$374,715	30,200	$1,535,985	$673,145	40,200	$2,001,835	$693,495	64,400	$3,442,175	$1,297,505
MAGNITUDE OF UNCERTAINTY		plus 3%	minus 5%		plus 5%	minus 10%		plus 8%	minus 12%		plus 10%	minus 15%		plus 15%	minus 10%

NOTES:
1) Above cost do not include Bond's, Insurances or Taxes
2) No winter work assumed
3) All heavy cranes not in above prices.

Activity Description	ACTIVITIES INCLUDED UNDER DESCRIPTION
Receive/Uncrate Nacelle,Blades, Rotors & Towers	Uncrate Nacelles, Rotors & Blades, Unloading & Sorting,Site distribution
Rig & Set Tower Sections	Rig, Set, & Torque all Tower Sections, Non Productive Time
Grout & Torque Bases	Grout Base Sections,Tension Anchor Bolts,Anchor Bolt Tension Verification
Assemble Rotors/Blades & Nacelle	Assemble Blades to Rotors,Assemble & Prep Nacelle, Hay bales & dunnage
Rig & Set Nacelle & Blades	Rig & set Nacelle,Torque Nacelle,Rig & set Rotor assembly, Torque Rotor Assembly to Spindle, Premium Time (Labor)
Install Safety Equipment	Install Safety climbing devices,Set Controller & Lower power cable from Nacelle to Control Cabinet, Complete Ladder & Platform Assemblies
General Conditions	See attached worksheet for break down on whats included

GENERAL CONDITIONS

GLOBAL ENERGY CONCEPTS, LLC.

750 & 1500 MW UNITS

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
PROFESSIONAL SERVICES					
CONSULTING ENGINEER					
TECH.SERVICES SAFETY					
**TOTAL PROFESSIONAL SERVICES	0	70	0	24	94
PERMITS & FEES					
**TOTAL PERMITS & FEES	0	0	0	0	0
CONST. SERVICES & MISC.					
PHOTOGRAPHS-MAM					
**TOTAL CONST.SERVICES & MISC.	0	5	0	0	5

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
ON-SITE PERSONNEL					
PROJECT MANAGER					
GENERAL SUPERINTENDENT					
ASSISTANT SUPERINTENDENT					
FIELD ENGINEER #1					
SECRETARY					
FOREMAN SUPPLEMENT					
**TOTAL ON-SITE PERSONNEL	1061	257	0	0	1318
RELOCATION & TRAVEL					
OFFICE TRAVEL-GRAND RAPIDS					
TRADES TRAVEL SUBSISTANCE					
EMPLOYEE RELATIONS					
**TOTAL RELOCATION & TRAVEL	0	385	0	0	385

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
FIELD OFFICE EXPENSES					
OFFICE EQUIPMENT-MAM					
DUPLICATING MACHINE-MAM					
FAX MACHINE-MAM					
COMPUTER-MAM					
COMPUTER SOFTWARE					
OFFICE SUPPLIES					
POSTAGE/UPS					
OVERNIGHT MAIL					
**TOTAL FIELD OFFICE EXPENSES	0	102	0	0	102
TEMPORARY FACILITIES					
MAM OFFICE >12 X 50					
SET UP OFFICE TRAILERS					
OFFICE LINK					
TOOL TRAILER					
SET UP TOOL TRAILER					
WORK SHACK (SKID VAN)					
PROJECT SIGN					
**TOTAL TEMPORARY FACILITIES	68	114	0	0	182

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
MOVING & TRANSPORTATION					
FREIGHT					
MOVE OFFICE TRAILERS					
MOVE TOOL TRAILERS					
LOAD & UNLOAD					
**TOTAL MOVING & TRANSPORTATION	6	160	0	0	166
CONSTRUCTION UTILITIES					
ELECTRICAL SERVICE					
TEMPORARY LIGHT/POWER DIST.					
ELECTRICAL ENERGY					
TELEPHONE-MAM					
PHONE LINE INSTALLATION					
TELE.-DATA COMM'TNS.					
DRINKING WATER					
SANITATION					
**TOTAL CONSTRUCTION UTILITIES	6	91	0	94	191
HEATING & VENTILATION					
**TOTAL HEATING & VENTILATION	0	0	0	0	0

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
CONSTRUCTION EQUIPMENT					
45 TON HYDRO					
100 TON HYDRO					
CRAWLER CRANE FREIGHT					
ROUGH TERRAIN FORKLIFT					
AUTOMATIC LEVEL					
RADIOS					
BOLT TORQUE EQUIP.					
PICKUP O.S. LEASE					
PICKUP JOB					
EQUIPMENT OPERATING EXPENSE					
EQUIPMENT REPAIRS					
SMALL TOOLS/CONSUMABLES					
EQUIPMENT OPERATOR					
MOBILE CRANE OPERATOR					
OILER					
**TOTAL CONSTRUCTION EQUIPMENT	523	3415	1022	378	5338
QUALITY					
**TOTAL QUALITY	0	0	0	0	0
SAFETY					
PRE-EMPLOYMENT PHYSICAL					
SAFETY INCENTIVE					
**TOTAL SAFETY	0	60	0	0	60

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
CLEAN-UP					
RUBBISH REMOVAL					
FINAL CLEAN UP					
**TOTAL CLEAN-UP	12	34	0	0	46
PROJECT STARTUP & CLOSEOUT					
**TOTAL PROJ. STARTUP & CLEANUP	0	0	0	0	0
***TOTAL GENERAL REQUIREMENTS	$1,676	$4,693	$1,022	$496	$7,887

GENERAL CONDITIONS

GLOBAL ENERGY CONCEPTS, LLC.
2500 & 3500 MW UNITS

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
PROFESSIONAL SERVICES					
CONSULTING ENGINEER					
TECH.SERVICES SAFETY					
**TOTAL PROFESSIONAL SERVICES	0	158	0	54	212
PERMITS & FEES					
**TOTAL PERMITS & FEES	0	0	0	0	0
CONST. SERVICES & MISC.					
PHOTOGRAPHS-MAM					
**TOTAL CONST.SERVICES & MISC.	0	11	0	0	11
ON-SITE PERSONNEL					
PROJECT MANAGER					
GENERAL SUPERINTENDENT					
ASSISTANT SUPERINTENDENT					
FIELD ENGINEER #1					
SECRETARY					
FOREMAN SUPPLEMENT					
**TOTAL ON-SITE PERSONNEL	384	58	0	0	442
RELOCATION & TRAVEL					
OFFICE TRAVEL-GRAND RAPIDS					
TRADES TRAVEL SUBSISTANCE					
EMPLOYEE RELATIONS					
**TOTAL RELOCATION & TRAVEL	0	866	0	0	866

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
FIELD OFFICE EXPENSES					
OFFICE EQUIPMENT-MAM					
DUPLICATING MACHINE-MAM					
FAX MACHINE-MAM					
COMPUTER-MAM					
COMPUTER SOFTWARE					
OFFICE SUPPLIES					
POSTAGE/UPS					
OVERNIGHT MAIL					
**TOTAL FIELD OFFICE EXPENSES	0	228	0	0	228
TEMPORARY FACILITIES					
MAM OFFICE >12 X 50					
SET UP OFFICE TRAILERS					
OFFICE LINK					
TOOL TRAILER					
SET UP TOOL TRAILER					
WORK SHACK (SKID VAN)					
PROJECT SIGN					
**TOTAL TEMPORARY FACILITIES	167	269	0	0	436

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
MOVING & TRANSPORTATION					
FREIGHT					
MOVE OFFICE TRAILERS					
MOVE TOOL TRAILERS					
LOAD & UNLOAD					
**TOTAL MOVING & TRANSPORTATION	14	360	0	0	374
CONSTRUCTION UTILITIES					
ELECTRICAL SERVICE					
TEMPORARY LIGHT/POWER DIST.					
ELECTRICAL ENERGY					
TELEPHONE-MAM					
PHONE LINE INSTALLATION					
TELE.-DATA COMM'TNS.					
DRINKING WATER					
SANITATION					
**TOTAL CONSTRUCTION UTILITIES	14	202	0	212	428
HEATING & VENTILATION					
**TOTAL HEATING & VENTILATION	0	0	0	0	0

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
CONSTRUCTION EQUIPMENT					
45 TON HYDRO					
100 TON HYDRO					
CRAWLER CRANE FREIGHT					
ROUGH TERRAIN FORKLIFT					
AUTOMATIC LEVEL					
RADIOS					
BOLT TORQUE EQUIP.					
PICKUP O.S. LEASE					
PICKUP JOB					
EQUIPMENT OPERATING EXPENSE					
EQUIPMENT REPAIRS					
SMALL TOOLS/CONSUMABLES					
EQUIPMENT OPERATOR					
MOBILE CRANE OPERATOR					
OILER					
**TOTAL CONSTRUCTION EQUIPMENT	1174	6121	2307	515	10117
QUALITY					
**TOTAL QUALITY	0	0	0	0	0
SAFETY					
PRE-EMPLOYMENT PHYSICAL					
SAFETY INCENTIVE					
**TOTAL SAFETY	0	135	0	0	135

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
CLEAN-UP					
RUBBISH REMOVAL					
FINAL CLEAN UP					
**TOTAL CLEAN-UP	27	77	0	0	104
PROJECT STARTUP & CLOSEOUT					
**TOTAL PROJ. STARTUP & CLEANUP	0	0	0	0	0
***TOTAL GENERAL REQUIREMENTS	1780	8485	2307	781	$13,353.00

GENERAL CONDITIONS

GLOBAL ENERGY CONCEPTS, LLC.
5000 MW UNITS

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
PROFESSIONAL SERVICES					
CONSULTING ENGINEER					
TECH.SERVICES SAFETY					
**TOTAL PROFESSIONAL SERVICES	0	294	0	96	390
PERMITS & FEES					
**TOTAL PERMITS & FEES	0	0	0	0	0
CONST. SERVICES & MISC.					
PHOTOGRAPHS-MAM					
**TOTAL CONST.SERVICES & MISC.	0	18	0	0	18

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
ON-SITE PERSONNEL					
PROJECT MANAGER					
GENERAL SUPERINTENDENT					
ASSISTANT SUPERINTENDENT					
FIELD ENGINEER #1					
SECRETARY					
FOREMAN SUPPLEMENT					
**TOTAL ON-SITE PERSONNEL	4265	1033	0	0	5298
RELOCATION & TRAVEL					
OFFICE TRAVEL-GRAND RAPIDS					
TRADES TRAVEL SUBSISTANCE					
EMPLOYEE RELATIONS					
**TOTAL RELOCATION & TRAVEL	0	1552	0	0	1552

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
FIELD OFFICE EXPENSES					
OFFICE EQUIPMENT-MAM					
DUPLICATING MACHINE-MAM					
FAX MACHINE-MAM					
COMPUTER-MAM					
COMPUTER SOFTWARE					
OFFICE SUPPLIES					
POSTAGE/UPS					
OVERNIGHT MAIL					
**TOTAL FIELD OFFICE EXPENSES	0	409	0	0	409
TEMPORARY FACILITIES					
MAM OFFICE >12 X 50					
SET UP OFFICE TRAILERS					
OFFICE LINK					
TOOL TRAILER					
SET UP TOOL TRAILER					
WORK SHACK (SKID VAN)					
PROJECT SIGN					
**TOTAL TEMPORARY FACILITIES	273	454	0	0	727

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
MOVING & TRANSPORTATION					
FREIGHT					
MOVE OFFICE TRAILERS					
MOVE TOOL TRAILERS					
LOAD & UNLOAD					
**TOTAL MOVING & TRANSPORTATION	24	640	0	0	664
CONSTRUCTION UTILITIES					
ELECTRICAL SERVICE					
TEMPORARY LIGHT/POWER DIST.					
ELECTRICAL ENERGY					
TELEPHONE-MAM					
PHONE LINE INSTALLATION					
TELE.-DATA COMM'TNS.					
DRINKING WATER					
SANITATION					
**TOTAL CONSTRUCTION UTILITIES	24	361	0	376	761
HEATING & VENTILATION					
**TOTAL HEATING & VENTILATION	0	0	0	0	0

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
CONSTRUCTION EQUIPMENT					
45 TON HYDRO					
100 TON HYDRO					
CRAWLER CRANE FREIGHT					
ROUGH TERRAIN FORKLIFT					
AUTOMATIC LEVEL					
RADIOS					
BOLT TORQUE EQUIP.					
PICKUP O.S. LEASE					
PICKUP JOB					
EQUIPMENT OPERATING EXPENSE					
EQUIPMENT REPAIRS					
SMALL TOOLS/CONSUMABLES					
EQUIPMENT OPERATOR					
MOBILE CRANE OPERATOR					
OILER					
**TOTAL CONSTRUCTION EQUIPMENT	2103	11666	4138	1520	19427
QUALITY					
**TOTAL QUALITY	0	0	0	0	0
SAFETY					
PRE-EMPLOYMENT PHYSICAL					
SAFETY INCENTIVE					
**TOTAL SAFETY	0	240	0	0	240

DESCRIPTION	TOTAL COST LABOR	MAT'L.	EQUIP.	SUB.	TOTAL
CLEAN-UP					
RUBBISH REMOVAL					
FINAL CLEAN UP					
**TOTAL CLEAN-UP	48	136	0	0	184
PROJECT STARTUP & CLOSEOUT					
**TOTAL PROJ. STARTUP & CLEANUP	0	0	0	0	0
***TOTAL GENERAL REQUIREMENTS	6737	16803	4138	1992	$29,670.00

GLOBAL ENERGY CONCEPTS, LLC.

MEGAWATT-SCALE WIND TURBINE CONSTRUCTION

Tower section assembly for 3500 & 5000 MW Units

Assembly Work Pads

36'-0" x 83'-0" x 1'-0" - 4 req'd.

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Concrete	444	CY	3	148	$40	$5,964	$80	$35,520	$41,484
Reinforcing steel	43,373	LBS	120	361	$40	$14,458		$0	$14,458
Concrete forming	238	SF	8	30	$40	$1,200	$3	$714	$1,914
Concrete Curing	3226	SF	250	13	$0	$0	$0.10	$323	$323
Concrete Finishing	3226	SF	70	46	$40	$1,840		$0	$1,840
Embedded Plates	3312	LBS	100	34	$40	$1,360	$1.25	$4,140	$5,500
Cradle Section	48	EA	1	48	$40	$1,920	$200	$9,600	$11,520
Center Cradle Section	24	EA	2	12	$40	$480	$15	$360	$840
Top & Bottom Templates	8	EA	0	0	$0	$0	$1,500	$12,000	$12,000
Screw Jacks	60	EA	0	0	$0	$0	$30	$1,800	$1,800
TOTALS				**692**		**$27,222**		**$64,457**	**$91,679**

WELDED QUARTER SECTIONS OF TOWERS
(ONLY THREE TOWER SECTIONS TO BE QUARTERED,OTHER TWO CAN BE SHIPPED AS WHOLE SECTIONS)

Tower Section Assembly 3500 MW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	60	EA	4	12	$40	$480	$0.00	$0	$480
Quarter-Section Weld	5041	INCHES	16	315	$40	$12,600	$0.58	$2,924	$15,524
Half-Section Weld	5041	INCHES	16	315	$40	$12,600	$0.58	$2,924	$15,524
Top & Bottom Template	32	EA	0.25	128	$40	$5,120	$0.00	$0	$5,120
Move Cradles	48	EA	2	24	$40	$960	$0.00	$0	$960
Lifting Eyes	16	EA	1	16	$40	$640	$35.00	$560	$1,200
Paint (section 1)	5316	SF	80	67	$40	$2,680	$0.50	$2,658	$5,338
Paint (section 2)	5006	SF	80	63	$40	$2,520	$0.50	$2,503	$5,023
Paint (section 3)	4496	SF	80	56	$40	$2,240	$0.50	$2,248	$4,488
Non-Productive Time	3%	MHRS		30	$40	$1,195	$0.00	$0	$1,195
X-RAY TEST	60	EA	1	60	$65	$3,900	$20.00	$1,200	$5,100
Weld Correction (1%)	68	INCHES	16	5	$40	$200	$0.58	$39	$239
Load & Transport Towers	3	SECTIONS	0.18	16	$40	$640	$0.00	$0	$640
					$0	$0	$0.00	$0	$0
TOTALS				**1107**		**$45,775**		**$15,056**	**$60,831**
Project Cost (Based on 50 towers)				**55,344**		**$2,288,760**		**$752,800**	**$3,041,560**

WELDED QUARTER SECTIONS OF TOWERS
(ONLY FIVE TOWER SECTIONS TO BE QUARTERED,OTHER TWO CAN BE SHIPPED AS WHOLE SECTIONS)

Tower Section Assembly 5000 MW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	120	EA	4	30	$40	$1,200	$0	$0	$1,200
Quarter-Section Weld	8780	INCHES	16	549	$40	$21,960	$0.58	$5,092	$27,052
Half-Section Weld	8780	INCHES	16	549	$40	$21,960	$0.58	$5,092	$27,052
Top & Bottom Template	80	EA	0.25	280	$40	$11,200	$0	$0	$11,200
Move Cradles	120	EA	2	60	$40	$2,400	$0	$0	$2,400
Lifting Eyes	40	EA	1	40	$40	$1,600	$35	$1,400	$3,000
Paint (section 1)	6784	SF	80	85	$40	$3,392	$0.50	$3,392	$6,784
Paint (section 2)	6256	SF	80	78	$40	$3,128	$0.50	$3,128	$6,256
Paint (section 3)	5803	SF	80	73	$40	$2,902	$0.50	$2,902	$5,803
Paint (section 4)	5276	SF	80	66	$40	$2,638	$0.50	$2,638	$5,276
Paint (section 5)	4824	SF	80	60	$40	$2,412	$0.00	$0	$2,412
Non-Productive Time	3%	MHRS		56	$40	$2,244	$0.00	$0	$2,244
X-RAY TEST	100	EA	1	100	$65	$6,500	$0.00	$0	$6,500
Weld Correction (1%)	175	INCHES	16	11	$40	$440	$0.50	$88	$528
Load & Transport Towers	5	SECTIONS	0.18	28	$40	$1,120	$20.00	$100	$1,220
TOTALS				**2065**		**$85,095**		**$23,832**	**$108,927**
Project Cost (Based on 50 towers)				**103,244**		**$4,254,762**		**$1,191,590**	**$5,446,352**

BOLTED CONNECTIONS
(ONLY THREE TOWER SECTIONS TO BE QUARTERED,OTHER TWO CAN BE SHIPPED AS WHOLE SECTIONS)

Tower Section Assembly 3500 MW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	60	EA	4	12	$40	$480	$0	$0	$480
Quarter-Section Bolts	330	BOLTS	10	30	$40	$1,200	$0.00	$0	$1,200
Half-Section Bolts	330	BOLTS	10	30	$40	$1,200	$0.00	$0	$1,200
Top & Bottom Template	32	EA	0.25	128	$40	$5,120	$0	$0	$5,120
Move Cradles	48	EA	2	24	$40	$960	$0	$0	$960
Lifting Eyes	16	EA	1	16	$40	$640	$35	$560	$1,200
Paint (section 1)	10	SF	5	2	$40	$80	$0.50	$5	$85
Paint (section 2)	10	SF	5	2	$40	$80	$0.50	$5	$85
Paint (section 3)	10	SF	5	2	$40	$80	$0.50	$5	$85
Non-Productive Time				45	$40	$1,800	$0	$0	$1,800
Torqoe Test Bolts	330	BOLTS	30	11	$50	$550		$0	$550
TOTALS				302		$12,190		$575	$12,765
Project Cost (Based on 50 towers)				**15,100**		**$609,500**		**$28,750**	**$638,250**

BOLTED CONNECTIONS
(ONLY FIVE TOWER SECTIONS TO BE QUARTERED,OTHER TWO CAN BE SHIPPED AS WHOLE SECTIONS)

Tower Section Assembly 5000 MW

Description	QTY.	UNITS	UNITS/ MHR	TOTAL MHRS	COST/ MHR	TOTAL LABOR	MAT'L. UNIT $$	TOTAL MAT'L.	TOTAL L & M
Screw Jacks	120	EA	4	30	$40	$1,200	$0	$0	$1,200
Quarter-Section Bolt	558	BOLTS	10	58	$40	$2,320	$0.00	$0	$2,320
Half-Section Bolt	558	BOLTS	10	58	$40	$2,320	$0.00	$0	$2,320
Top & Bottom Template	80	EA	0.25	280	$40	$11,200	$0	$0	$11,200
Move Cradles	120	EA	2	60	$40	$2,400	$0	$0	$2,400
Lifting Eyes	40	EA	1	40	$40	$1,600	$35	$1,400	$3,000
Paint (section 1)	10	SF	5	2	$40	$80	$0.50	$5	$85
Paint (section 2)	10	SF	5	2	$40	$80	$0.50	$5	$85
Paint (section 3)	10	SF	5	2	$40	$80	$0.50	$5	$85
Paint (section 4)	10	SF	5	2	$40	$80	$0.50	$5	$85
Paint (section 5)	10	SF	5	2	$40	**$80**	$0.50	**$5**	**$85**
Non-Productive Time				60	$40	**$2,400**	0	**$0**	**$2,400**
Torque Test Bolts	1116	BOLTS	30	37	$40	**$1,480**	$0	**$0**	**$1,480**
						$0	0	**$0**	**$0**
						$0	0	**$0**	**$0**
TOTALS				**633**		**$25,320**		**$1,425**	**$26,745**
Project Cost (Based on 50 towers)				**31,650**		**$1,266,000**		**$71,250**	**$1,337,250**

Appendix R
Lampson Estimates

OPTION # 1: This option will make use of 2 cranes per turbine. The first crane is assumed to start erecting the tower sections sufficiently ahead of the nacelle installation so as to produce a smooth schedule. At the client's option either the first crane can continue around behind the nacelle installation crane and erect the hub and blades or the nacelle erection crane can remain at each turbine until installation of the hub and blades is complete or some combination of each

Option # 2: This option will make use of 1 crane per turbine. The crane will either fully complete each turbine before moving to the next or move from turbine to turbine after completing only a portion of each (I.e., erect the towers) before returning to the start and erecting the next items (I.e., erect the nacelle and rotor).

	750 kW --- OPTION # 1		750 kW --- OPTION # 2
1) Brief Description Of Lifting Approach:			
1a - Number of cranes required per turbine	2		1
1b - Crane assignment	# 1 - Tower & Rotor	# 2 - Nacelle	# 1 - Tower, Nacelle & Rotor
1c - Alternative lifting approach, if applicable	-------------------------------	-------------------------------	-------------------------------
2) For Each Type Of Crane Identified Provide:			
2a - Crane type, manufacturer & model	Manitowoc - 4100 S1	Manitowoc - 4600 S4	Manitowoc - 4600 S4
2b - Boom length, capacity & reach	79 Meter (260')	85 Meter (280')	85 Meter (280')
	37,800 Kg @ 14 Meters (Boom)	36,400 Kg @ 23 Meter (Boom)	63,100 Kg @ 16 Meter (Boom)
	16,500 Kg @ 24 Meters (Boom)	-------------------------	36,400 Kg @ 23 Meter (Boom)
2c - Description of crane operation	Tracked	Tracked	Tracked
2d - Monthly Rental Costs (Bare rates - no labor)			
1 - Operating Rates (based on 176 hrs/month)	$15,000	$32,000	$32,000
2 - Stand-by Rates	$10,000	$24,000	$24,000
3 - Overtime Rates (per hour)	$57	$121	$121
2e - Manufactures specification sheets, tables or graphs	See Attachment 10.1.1	See Attachment 10.1.1	See Attachment 10.1.1
2f - Availability of equipment, scheduling requirements, lead time	30 days	60 days	60 days
2g - Crane pad/Working area dimensions	243 SqM	110 SqM	1 @ 250 SqM + 1 @ 110 SqM
2h - Weather operations limits - temperature, wind, visibility, precipitation	Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility		Min. Temp -30 F, Wind up to 9 m/s (20 MPH), Good visibility
2i - Other operation limits	Verify Training of Operating Crew	Verify Training of Operating Crew	Verify Training of Operating Crew
2) Crane Crew For Each Turbine Case:			
2a - Crew size and responsibilities	2 Total - 1 Operator & 1 Oiler	2 Total - 1 Operator & 1 Oiler	2 Total - 1 Operator & 1 Oiler
2b - Estimated hourly crew costs (straight time)	$130	$130	$130
2c - Estimated lodging/per diem costs (per person)	$75	$75	$75
2d - Travel costs ($/mile)	$1.25	$1.25	$1.25
3) Crane Assembly:			
3a - Estimated crane assembly cost	$10,000	$18,000	$18,000
3b - On-site relocation time/logistics (Includes One Layer Crane Mat Pad)	4 Hours @ Operating Rate	2 Hours @ Operating Rate	6 Hours @ Operating Rate
4) Mobilization/Demobilization:			
4a - Brief Description Of Logistics	Deliver carbody & house, install side frames, install boom, wire & block - boom up	Deliver carbody & house, install side frames, install boom, wire & block - boom up	Deliver carbody & house, install side frames, install boom, wire & block - boom up
4b - Schedule/time requirements	12 Hours Up & 12 Hours Down	24 Hours UP & 24 Hours Down	24 Hours Up & 24 Hours Down
4c - Identify costs separately			
1 - Lampson Supervisor	24 hrs @ $75/hr	48 hrs @ $75/hr	48 hrs @ $75/hr
2 - Iron Workers (4)	96 hrs @ $65/hr	192 hrs @ $65/hr	192 hrs @ $65/hr
3 - 50 ton hydraulic crane	32 hrs @ $370/hr (2 cranes)	24 hrs @ $185/hr	24 hrs @ $185/hr
4 - (1) 150 ton truck crane	-	24 hrs @ $325/hr	24 hrs @ $325/hr
5 -			
4d - Fixed Costs - Freight Estimate to and from project - Total	$40,000	$60,000	$60,000
4e - Mileage or time dependent costs			
5) Materials And Consumables:			
5a - Cribbing (One Layer Crane Mat Pad) @ $2.50/sq ft	1 Ea. @ 243 SqM (2615 SqFt)	1 Ea. @ 110 SqM (1185 SqFt)	1 Ea @ 243 SqM + 1 Ea. @ 110 SqM = 353 SqM (3800 SqFt)
5b - Fuel @ $1.50/gal	220 gal/wk	250 gal/wk	250 gal/wk
6) Off-site And On-site Road Requirements:			
6a - Road geometry			
1 - Maximum grade, %	8%	8%	8%
2 - Maximum road crown, M	Empty 2%, loaded 0%	Empty 2%, loaded 0%	Empty 2%, loaded 0%
3- Minimum curve radius	50-100 ft	50-100 ft	50-100 ft
4 - Minimum road width, M	26 ft	30 ft	30 ft
6b - Surface limitations (gravel, asphalt)	gravel	gravel	gravel
6c - General road design/loading requirements	100% compaction	100% compaction	100% compaction
6d - Off-site equipment transportation requirements			
1- Oversized load permits required	y	y	y
2- Route planning required	y	y	y
3 - Escorts required	y	y	y
7) Job Site Facility Needs:			
7a - Site Office/storage			
1 - Site Office	share	share	share
2 - Site Storage	y	y	y
3 - Site Amenities (Lunchroom, Toilets, etc.)	y	y	y
8) General Industry Overhead, Fees and Profit:			
1 - Overheads			
2 - Fees			
3 - Profit			
9) Overall Project Crane Costs Per Facility:			
9a - Combine crew, equipment, material, expendables, mob/demob, overhead, profit, etc. into total costs per facility and per turbine			
1 - Total cost per facility (50 turbines farm)			
2 - Total cost per turbine			
9b - Provide total schedule per facility			

OPTION # 1: This option will make use of 2 cranes per turbine. The first crane is assumed to start erecting the tower sections sufficiently ahead of the nacelle installation so as to produce a smooth schedule. At the client's option either the first crane can continue around behind the nacelle installation crane and erec the hub and blades or the nacelle erection crane can remain at each turbine until installation of the hub and blades is complete or some combination of each

Option # 2: This option will make use of 1 crane per turbine. The crane will either fully complete each turbine before moving to the next or move from turbine to turbine after completing only a portion of each (I.e., erect the towers) before returning to the start and erecting the next items (I.e., erect the nacelle and rotor).

	1500 kW --- OPTION # 1		**1500 kW --- OPTION # 2**
1) Brief Description Of Lifting Approach:			
1a - Number of cranes required per turbine	2		1
1b - Crane assignment	# 1 - Tower & Rotor	# 2 - Nacelle	# 1 - Tower, Nacelle & Rotor
1c - Alternative lifting approach, if applicable	------------------------------	------------------------------	------------------------------
2) For Each Type Of Crane Identified Provide:			
2a - Crane type, manufacturer & model	Manitowoc - 4600 S5	Lampson LTL - 600	Lampson LTL - 600
2b - Boom length, capacity & reach	82 Meter Boom + 18 Meter Jib	85 Meter Boom + 24 Meter Jib	85 Meter Boom + 24 Meter Jib
	64,000 Kg @ 16 Meters (Boom)	170,900 Kg @ 30 Meters (Jib)	170,900 Kg @ 30 Meters (Jib)
	34,500 Kg @ 22 Meters (Jib)	-------------------------	-------------------------
2c - Description of crane operation	Tracked	Counter Balanced - 400 Te. Cwt	Counter Balanced - 400 Te. Cwt
2d - Monthly Rental Costs (Bare rates - no labor)			
1 - Operating Rates (based on 176 hrs/month)	$37,500	$90,000	$90,000
2 - Stand-by Rates	$25,000	$60,000	$60,000
3 - Overtime Rates (per hour)	$142	$341	$341
2e - Manufactures specification sheets, tables or graphs	See Attachment 10.1.2	See Attachment 10.1.2	See Attachment 10.1.2
2f - Availability of equipment, scheduling requirements, lead time	60 days	120 days	120 days
2g - Crane pad/Working area dimensions	550 SqM -- shared crane pad		1500 SqM
2h - Weather operations limits - temperature, wind, visibility, precipitation	Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility		Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility
2i - Other operation limits			
2) Crane Crew For Each Turbine Case:			
2a - Crew size and responsibilities	2 Total - 1 Operator & 1 Oiler	3 Total - 3 Operators	3 Total - 3 Operators
2b - Estimated hourly crew costs (straight time)	$130	$195	$195
2c - Estimated lodging/per diem costs (per diem)	$75	$75	$75
2d - Travel costs ($/mile)	$1.25	$1.25	$1.25
3) Crane Assembly:			
3a - Estimated crane assembly costs	$18,000	$65,000	$50,000
3b - On-site relocation time/logistics (Includes One Layer Crane Mat Pad)	4 Hours @ Operating Rate	4 Hours @ Operating Rate	21 Hours @ Operating Rate
4) Mobilization/Demobilization:			
4a - Brief Description Of Logistics	Deliver carbody & house, install side frames, install boom/jib, wire & block & boom up	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up
4b - Schedule/time requirements	24 Hours UP & 24 Hours Down	80 Hours Up & 80 Hours Down	80 Hours UP & 80 Hours Down
4c - Identify costs separately			
1 - Lampson Supervisor	48 hrs @ $75/hr	160 hrs @ $75/hr	160 hrs @ $75/hr
2 - Iron Workers (number shown)	192 hrs @ $65/hr (4)	960 hrs @ $65/hr (6)	960 hrs @ $75/hr (6)
3 -	-	-	-
4 - (1) 150 ton truck crane	48 hrs @ $325/hr	160 hrs @ $325/hr	160 hrs @ $325/hr
5 -			
4d - Fixed Costs - Transporation Freight To and From Project	$70,000	$120,000	$120,000
4e - Mileage or time dependent costs			
5) Materials And Consumables:			
5a - Cribbing (One Layer Crane Mat Pad) @ $2.50/sq ft	2 Ea. @ 550 SqM = 1100 SqM (11,900 SqFt)		1 Ea. @ 1500 SqM (16150 SqFt)
5b - Fuel @ $1.50/gal	250 gal/wk	650 gal/wk	650 gal/wk
6) Off-site And On-site Road Requirements:			
6a - Road geometry			
1 - Maximum grade, %	8%	8%	0.08
2 - Maximum road crown, M	Empty 2%, loaded 0%	Empty 2%, loaded 0%	Empty 2%, loaded 0%
3- Minimum curve radius	50-100 ft	50-100 ft	50-100 ft
4 - Minimum road width, M	30 ft	30 ft	30 ft
6b - Surface limitations (gravel, asphalt)	gravel	gravel	gravel
6c - General road design/loading requirements	100% compaction	100% compaction	100% compaction
6d - Off-site equipment transportation requirements			
1- Oversized load permits required	y	y	y
2- Route planning required	y	y	y
3 - Escorts required	y	y	y
7) Job Site Facility Needs:			
7a - Site Office/storage			
1 - Site Office	share	share	share
2 - Site Storage	y	y	y
3 - Site Amenities (Lunchroom, Toilets, etc.)	y	y	y
8) General Industry Overhead, Fees and Profit:			
1 - Overheads			
2 - Fees			
3 - Profit			
9) Overall Project Crane Costs Per Facility:			
9a - Combine crew, equipment, material, expendables, mob/demob, overhead, profit, etc. into total costs per facility and per turbine			
1 - Total cost per facility (50 turbines farm)			
2 - Total cost per turbine			
9b - Provide total schedule per facility			

OPTION # 1: This option will make use of 2 cranes per turbine. The first crane is assumed to start erecting the tower sections sufficiently ahead of the nacelle installation so as to produce a smooth schedule. At the client's option either the first crane can continue around behind the nacelle installation crane and erect the hub and blades or the nacelle erection crane can remain at each turbine until installation of the hub and blades is complete or some combination of each.

Option # 2: This option will make use of 1 crane per turbine. The crane will either fully complete each turbine before moving to the next or move from turbine to turbine after completing only a portion of each (I.e., erect the towers) before returning to the start and erecting the next items (I.e., erect the nacelle and rotor).

	2500 kW --- OPTION # 1		**2500 kW --- OPTION # 2**
1) Brief Description Of Lifting Approach:			
1a - Number of cranes required per turbine	2		1
1b - Crane assignment	# 1 - Tower & Rotor	# 2 - Nacelle	# 1 - Tower, Nacelle & Rotor
1c - Alternative lifting approach, if applicable	-------------------------------	-------------------------------	-------------------------------
2) For Each Type Of Crane Identified Provide:			
2a - Crane type, manufacturer & model	Lampson LTL - 850	Lampson LTL - 850	Lampson LTL - 850
2b - Boom length, capacity & reach	98 Meter Boom + 37 Meter Jib	98 Meter Boom + 37 Meter Jib	98 Meter Boom + 37 Meter Jib
	207,400 Kg @ 34 Meters (Jib)	207,400 Kg @ 34 Meters (Jib)	207,400 Kg @ 34 Meters (Jib)
	-------------------------	-------------------------	-------------------------
2c - Description of crane operation	Counter-Balanced - 600 Te. Cwt.	Counter-Balanced - 600 Te. Cwt.	Counter-Balanced - 600 Te. Cwt.
2d - Monthly Rental Costs (Bare rates - no labor)			
1 - Operating Rates (based on 176 hrs/month)	$100,000	$100,000	$100,000
2 - Stand-by Rates	$66,666	$66,666	$66,666
3 - Overtime Rates (per hour)	$379	$379	$379
2e - Manufactures specification sheets, tables or graphs	See Attachment 10.1.3	See Attachment 10.1.3	See Attachment 10.1.3
2f - Availability of equipment, scheduling requirements, lead time	120 days	120 days	120 days
2g - Crane pad/Working area dimensions	1000 SqM		1000 SqM
2h - Weather operations limits - temperature, wind, visibility, precipitation	Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility		Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility
2i - Other operation limits	Verify Training of Operating Crew	Verify Training of Operating Crew	Verify Training of Operating Crew
2) Crane Crew For Each Turbine Case:			
2a - Crew size and responsibilities	3 Total - 3 operators	3 Total - 3 operators	3 Total - 3 operators
2b - Estimated hourly crew costs (straight time)	$195	$195	$195
2c - Estimated lodging/per diem costs (per person)	$75	$75	$75
2d - Travel costs ($/mile)	$1.25	$1.25	$1.25
3) Crane Assembly:			
3a - Estimated crane assembly costs	$75,000	$75,000	$75,000
3b - On-site relocation time/logistics (Includes One Layer Crane Mat Pad)	7 Hours	7 Hours	14 Hours
4) Mobilization/Demobilization:			
4a - Brief Description Of Logistics	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up
4b - Schedule/time requirements	96 Hours UP & 96 Hours Down	96 Hours Up & 96 Hours Down	96 Hours UP & 96 Hours Down
4c - Identify costs separately			
1 - Lampson Supervisor	192 hrs @ $75/hr	192 hrs @ $75/hr	192 hrs @ $75/hr
2 - Iron Workers	1152 hrs @ $65/hr	1152 hrs @ $65/hr	1152 hrs @ $65/hr
3 -			
4 - (1) 175 ton truck crane	144 hrs @ $350/hr	144 hrs @ $350/hr	144 hrs @ $350/hr
5 - 50 ton hydraulic crane	52 hrs @ $185/hr	52 hrs @ $185/hr	52 hrs @ $185/hr
4d - Fixed Costs - Transporation Freight To and From Project	$120,000	$120,000	$120,000
4e - Mileage or time dependent costs			
5) Materials And Consumables:			
5a - Cribbing (One Layer Crane Mat Pad) @ $2.50/sq ft	2 Ea. @ 1000 SqM = 2000 SqM (21500 SqFt)		1 Ea. @ 1000 SqM (10750 SqFt)
5b - Fuel @ $1.50/gal	650 gal/wk	250 gal/wk	650 gal/wk
6) Off-site And On-site Road Requirements:			
6a - Road geometry			
1 - Maximum grade, %	8%	8%	8%
2 - Maximum road crown, M	Empty 2%, loaded 0%	Empty 2%, loaded 0%	Empty 2%, loaded 0%
3- Minimum vertical curve, M	100 ft	100 ft	100 ft
4 - Minimum road width, M	30 ft	30 ft	30 ft
6b - Surface limitations (gravel, asphalt)	gravel	gravel	gravel
6c - General road design/loading requirements	100% compaction	100% compaction	100% compaction
6d - Off-site equipment transportation requirements			
1- Oversized load permits required	y	y	y
2- Route planning required	y	y	y
3 - Escorts required	y	y	y
7) Job Site Facility Needs:			
7a - Site Office/storage			
1 - Site Office	share	share	share
2 - Site Storage	y	y	y
3 - Site Amenities (Lunchroom, Toilets, etc.)	y	y	y
8) General Industry Overhead, Fees and Profit:			
1 - Overheads			
2 - Fees			
3 - Profit			
9) Overall Project Crane Costs Per Facility:			
9a - Combine crew, equipment, material, expendables, mob/demob, overhead, profit, etc. into total costs per facility and per turbine			
1 - Total cost per facility (50 turbines farm)			
2 - Total cost per turbine			
9b - Provide total schedule per facility			

OPTION # 1: This option will make use of 2 cranes per turbine. The first crane is assumed to start erecting the tower sections sufficiently ahead of the nacelle installation so as to produce a smooth schedule. At the client's option either the first crane can continue around behind the nacelle installation crane and erect the hub and blades or the nacelle erection crane can remain at each turbine until installation of the hub and blades is complete or some combination of each

Option # 2: This option will make use of 1 crane per turbine. The crane will either fully complete each turbine before moving to the next or move from turbine to turbine after completing only a portion of each (I.e., erect the towers) before returning to the start and erecting the next items (I.e., erect the nacelle and rotor).

	3500 kW --- OPTION # 1		3500 kW --- OPTION # 2
1) Brief Description Of Lifting Approach:			
1a - Number of cranes required per turbine	2		1
1b - Crane assignment	# 1 - Tower & Rotor	# 2 - Nacelle	# 1 - Tower, Nacelle & Rotor
1c - Alternative lifting approach, if applicable	------------------------------	------------------------------	------------------------------ ------------------------------
2) For Each Type Of Crane Identified Provide:			
2a - Crane type, manufacturer & model	Lampson LTL - 1000	Lampson LTL - 1100	Lampson LTL - 1100
2b - Boom length, capacity & reach	116 Meter Boom + 37 Meter Jib	122 Meter Boom + 37 Meter Jib	122 Meter Boom + 37 Meter Jib
	178,700 Kg @ 37 Meters (Jib)	213,600 Kg @ 32 Meters (Jib)	213,600 Kg @ 32 Meters (Jib)
	------------------------	------------------------	201,600 Kg @ 37 Meters (Jib)
2c - Description of crane operation	Counter-balanced - 900 Te. Cwt	Counter-balanced - 800 Te. Cwt	Counter-balanced - 800 Te. Cwt
2d - Monthly Rental Costs (Bare rates - no labor)			
1 - Operating Rates (based on 176 hrs/month)	$125,000	$140,000	$140,000
2 - Stand-by Rates	$83,250	$93,240	$93,240
3 - Overtime Rates (per hour)	$473	$530	$530
2e - Manufactures specification sheets, tables or graphs	See Attachment 10.1.4	See Attachment 10.1.4	See Attachment 10.1.4
2f - Availability of equipment, scheduling requirements, lead time	180 days	180 days	180 days
2g - Crane pad/Working area dimensions	1 @ 460 SqM + 1 @ 1500 SqM		1750 SqM
2h - Weather operations limits - temperature, wind, visibility, precipitation	Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility		Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility
2i - Other operation limits	Verify Training of Operating Crew	Verify Training of Operating Crew	Verify Training of Operating Crew
2) Crane Crew For Each Turbine Case:			
2a - Crew size and responsibilities	3 Total - 3 Operators	3 Total - 3 Operators	3 Total - 3 Operators
2b - Estimated hourly crew costs (straight time)	$195	$195	$195
2c - Estimated lodging/per diem costs (per person)	$75	$75	$75
2d - Travel costs ($/mile)	$1.25	$1.25	$1.25
3) Crane Assembly:			
3a - Estimated crane assembly costs	$125,000	$150,000	$100,000
3b - On-site relocation time/logistics (Includes One Layer Crane Mat Pad)	21 Hours	7 Hours	25 Hours
4) Mobilization/Demobilization:			
4a - Brief Description Of Logistics	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up
4b - Schedule/time requirements	180 Hours UP & 180 Hours Down	180 Hours UP & 180 Hours Down	180 Hours UP & 180 Hours Down
4c - Identify costs separately			
1 - Lampson Supervisor	360 hrs @ $75/hr	360 hrs @ $75/hr	360 hrs @ $75/hr
2 - Iron Workers (8)	2880 hrs @ $65/hr	2880 hrs @ $65/hr	2880 hrs @ $65/hr
3 -			
4 - (1) 200 ton crawler crane	120 hrs @ $350/hr	120 hrs @ $350/hr	120 hrs @ $350/hr
5 - (2) 50 ton hydraulic truck cranes	240 hrs @ $185/hr	240 hrs @ $185/hr	240 hrs @ $185/hr
4d - Fixed Costs - Transporation Freight To and From Project	$200,000	$220,000	$220,000
4e - Mileage or time dependent costs			
5) Materials And Consumables:			
5a - Cribbing (One Layer Crane Mat Pad) @ $2.50/sq ft	1 Ea. @ 460 SqM + 1 Ea. @ 1500 SqM = 1960 SqM (21,100 SqFt)		1 Ea. @ 1750 SqM (18,850 SqFt)
5b - Fuel @ $1.50/gal	700 gal/wk	700 gal/wk	700 gal/wk
6) Off-site And On-site Road Requirements:			
6a - Road geometry			
1 - Maximum grade, %	8%	8%	8%
2 - Maximum road crown, M	Empty 2%, loaded 0%	Empty 2%, loaded 0%	Empty 2%, loaded 0%
3- Minimum vertical curve, M	120 ft	120 ft	120 ft
4 - Minimum road width, M	32 ft	32 ft	32 ft
6b - Surface limitations (gravel, asphalt)	gravel	gravel	gravel
6c - General road design/loading requirements	100% compaction	100% compaction	100% compaction
6d - Off-site equipment transportation requirements			
1- Oversized load permits required	y	y	y
2- Route planning required	y	y	y
3 - Escorts required	y	y	y
7) Job Site Facility Needs:			
7a - Site Office/storage			
1 - Site Office	share	share	share
2 - Site Storage	y	y	y
3 - Site Amenities (Lunchroom, Toilets, etc.)	y	y	y
8) General Industry Overhead, Fees and Profit:			
1 - Overheads			
2 - Fees			
3 - Profit			
9) Overall Project Crane Costs Per Facility:			
9a - Combine crew, equipment, material, expendables, mob/demob, overhead, profit, etc. into total costs per facility and per turbine			
1 - Total cost per facility (50 turbines farm)			
2 - Total cost per turbine			
9b - Provide total schedule per facility			

OPTION # 1: This option will make use of 2 cranes per turbine. The first crane is assumed to start erecting the tower sections sufficiently ahead of the nacelle installation so as to produce a smooth schedule. At the client's option either the first crane can continue around behind the nacelle installation crane and erect the hub and blades or the nacelle erection crane can remain at each turbine until installation of the hub and blades is complete or some combination of each.

Option # 2: This option will make use of 1 crane per turbine. The crane will either fully complete each turbine before moving to the next or move from turbine to turbine after completing only a portion of each (I.e., erect the towers) before returning to the start and erecting the next items (I.e., erect the nacelle and rotor).

	5000 kW --- OPTION # 1		**5000 kW --- OPTION # 2**
1) Brief Description Of Lifting Approach:			
1a - Number of cranes required per turbine	2		1
1b - Crane assignment	# 1 - Tower & Rotor	# 2 - Nacelle	# 1 - Tower, Nacelle & Rotor
1c - Alternative lifting approach, if applicable	-------------------------------	-------------------------------	------------------------------- -------------------------------
2) For Each Type Of Crane Identified Provide:			
2a - Crane type, manufacturer & model	Lampson LTL - 1100	Lampson LTL - 1200 SII A	Lampson LTL - 1200 SII A
2b - Boom length, capacity & reach	122 Meter Boom + 55 Meter Jib	122 Meter Boom + 73 Meter Jib	122 Meter Boom + 73 Meter Jib
	307,800 Kg @ 28 Meters (Boom)	410,300 Kg @ 50 Meters (Jib)	410,300 Kg @ 50 Meters (Jib)
	168,000 Kg @ 40 Meters (Jib)	-------------------------	-------------------------
2c - Description of crane operation	Counter-balanced - 1000 Te. Cwt.	Counter-balanced - 1600 Te. Cwt.	Counter-balanced - 1600 Te. Cwt.
2d - Monthly Rental Costs (Bare rates - no labor)			
1 - Operating Rates (based on 176 hrs/month)	$140,000	$175,000	$175,000
2 - Stand-by Rates	$93,333	$116,667	$116,667
3 - Overtime Rates (per hour)	$530	$663	$663
2e - Manufactures specification sheets, tables or graphs	See Attachment 10.1.5	See Attachment 10.1.5	See Attachment 10.1.5
2f - Availability of equipment, scheduling requirements, lead time	180 days	180 days	180 days
2g - Crane pad/Working area dimensions	2400 SqM -- shared crane pad		1750 SqM
2h - Weather operations limits - temperature, wind, visibility, precipitation	Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility		Min. Temp. -30 F, Wind up to 9 m/s (20 MPH), Good visibility
2i - Other operation limits	Verify Training of Operating Crew	Verify Training of Operating Crew	Verify Training of Operating Crew
2) Crane Crew For Each Turbine Case:			
2a - Crew size and responsibilities	3 Total - 3 Operators	3 Total - 3 Operators	3 Total - 3 Operators
2b - Estimated hourly crew costs (straight time)	$195	$195	$195
2c - Estimated lodging/per diem costs (per person)	$75	$75	$75
2d - Travel costs ($/mile)	$1.25	$1.25	$1.25
3) Crane Assembly:			
3a - Estimated crane assembly costs	$190,000	$150,000	$150,000
3b - On-site relocation time/logistics (Includes One Layer Crane Mat Pad)	33 Hours	33 Hours	25 Hours
4) Mobilization/Demobilization:			
4a - Brief Description Of Logistics	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up	Deliver components, assemble crawlers, assemble mast, strut and stinger into triangle, install boom/jib, wire & block & boom up
4b - Schedule/time requirements	180 Hours UP & 180 Hours Down	240 Hours Up & 240 Hours Down	240 Hours UP & 240 Hours Down
4c - Identify costs separately			
1 - Lampson Supervisor	360 hrs @ $75/hr	480 hrs @ $75/hr	480 hrs @ $75/hr
2 - Iron Workers (8 to 10)	2880 hrs @ $65/hr (8)	4800 hrs @ $65/hr (10)	4800 hrs @ $65/hr (10)
3 -			
4 - (1) 200 ton crawler crane	80 hrs @ $350/hr	-	
5 - (1) 230 ton crawler crane	-	100 hrs @ $400/hr	100 hrs @ $400/hr
6 - 50 ton hydraulic crane (1 to 2)	160 hrs @ $185/hr	280 hrs @ $185	280 hrs @ $185
4d - Fixed Costs - Transporation Freight To and From Project	$220,000	$250,000	$250,000
4e - Mileage or time dependent costs			
5) Materials And Consumables:			
5a - Cribbing (One Layer Crane Mat Pad) @ $2.50/sq ft	2 Ea. @ 2400 SqM = 4800 SqM (51,700 SqFt)		1 Ea. @ 1750 SqM = 1750 SqM (18,900 SqFt)
5b - Fuel @ $1.50/gal	750 gal/wk	750 gal/wk	750 gal/wk
6) Off-site And On-site Road Requirements:			
6a - Road geometry			
1 - Maximum grade, %	8%	8%	0.08
2 - Maximum road crown, M	Empty 2%, loaded 0%	Empty 2%, loaded 0%	Empty 2%, loaded 0%
3- Minimum vertical curve, M	120 ft	120 ft	120 ft
4 - Minimum road width, M	32 ft	40 ft	40 ft
6b - Surface limitations (gravel, asphalt)	gravel	gravel	gravel
6c - General road design/loading requirements	100% compaction	100% compaction	100% compaction
6d - Off-site equipment transportation requirements			
1- Oversized load permits required	y	y	y
2- Route planning required	y	y	y
3 - Escorts required	y	y	y
7) Job Site Facility Needs:			
7a - Site Office/storage			
1 - Site Office	share	share	share
2 - Site Storage	y	y	y
3 - Site Amenities (Lunchroom, Toilets, etc.)	y	y	y
8) General Industry Overhead, Fees and Profit:			
1 - Overheads			
2 - Fees			
3 - Profit			
9) Overall Project Crane Costs Per Facility:			
9a - Combine crew, equipment, material, expendables, mob/demob, overhead, profit, etc. into total costs per facility and per turbine			
1 - Total cost per facility (50 turbines farm)			
2 - Total cost per turbine			
9b - Provide total schedule per facility			

Appendix S
Crane Purchase Evaluation

Desired Analysis:

1) Evaluate the costs of crane purchase in comparison to their rental costs.
2) Amortize the costs over the total wind farm and others in the region for erection and maintenance.

Approach:

1) Identify crane types, rental costs, purchase costs, and annual service/maintenance costs.
2) Evaluate differences between installation/erection activity and O & M activity. Differences might result in the use of different cranes.
3) Utilizing the numerator portion of the COE equation, determine the required annual crane usage that results in no impact to the COE.

$$\text{COE} = 0 = \frac{\text{Crane Capital Costs x F.C.}}{\text{AE}} + \frac{\text{Loaded Crane Rental Costs x } \textbf{Annual Usage}}{\text{AE}}$$

- OR -

$$\text{Crane Capital Costs x F.C.} = \text{Loaded Crane Rental Costs x } \textbf{Annual Usage}$$

4) Solve for **Annual Usage** and evaluate the result to determine if such usage rates could be reasonably expected at wind energy facilities.

5) Assumed Fixed Charge Rate of 10%.

NOTE: The crane models (types) represent 'service' cranes capable of blade removal, gearbox removal, generator removal (activities typically conducted during O & M). Intact nacelle removal would require the original installation crane. Costs for the original installation crane have not been evaluated but would be greater than those shown for each turbine size.

Turbine	kW	750	1500	2500	3500	5000
Rotor Dia	m	50	66	85	100	120
O & M Crane Type		4100-S1	4600-S4	LTL-600	LTL-600	LTL-1000
Crane Purchase Costs		$1,150,000	$2,250,000	$3,500,000	$3,500,000	$6,500,000
Fixed Charge Rate		0.1	0.1	0.1	0.1	0.1
Capital Costs x F.C.		$115,000	$225,000	$350,000	$350,000	$650,000
Loaded Hourly Operation Rate		$375	$490	$920	$920	$1,030
Annual Usage	hrs	307	459	380	380	631
Annual Usage	Months	1.7	2.6	2.2	2.2	3.6
Total Usage for 20 year project	hrs	6133	9184	7609	7609	12621
Usage every 3 years:	Months	5	8	6	6	11
Usage every 5 years	Months	9	13	11	11	18

[1] Hourly operation rates based on detailed crane cost estimates presented in Scenario 1 (typical costs) and include all costs from rental yard to site work and back to rental yard.

<u>Conclusions</u>:
Using the 750 kW turbine as an example:

1) In order for crane purchase to be cheaper than rental, the annual crane usage would need to be greater than 307 hrs - for each year of the 20 year project life. Or almost 2 months of crane work would be needed each year. This usage rate is most likely not achievable at one project with 50 turbines.

2) Annual crane service/maintenance costs are not included (nor readily available from Lampson). If the present value of these annual costs were added to the capital costs, the necessary annual usage to justify crane purchase would increase further (which is undesirable).

3) 'Reasonable' crane usage could be 1 month a year or less for a given project.

4) Incorporating crane usage at other projects in the region is highly dependant upon the assumptions. However, given the value of cranes to the wind industry, it is conceivable that the annual usage rates could be met for 20 years if one crane was available for 3 to 4 projects with 50 turbines. This assumption applies to projects with turbines of similar sizes or a very large crane for MW scale turbines could handle smaller turbines.

5) If a crane sized for one project of multi-megawatt scale turbines (2.5 - 5 MWs) is used at neighboring projects consisting of smaller turbines (750 kW), the time for crane mob, set-up, relocation, tear-down, and demob could be prohibitively long in comparison to rental of a crane sized for 750 kW turbines.

6) Generally most crane work will take place during a relatively small window of low wind months. It's likely that scheduling a crane work for 3 or 4 projects may not be possible, resulting in 1 or more projects needing to rent their own.

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13. ABSTRACT *(Maximum 200 words)* Through the National Renewable Energy Laboratory (NREL), the United States Department of Energy (DOE) implemented the Wind Partnership for Advanced Component Technologies (WindPACT) program. This program will explore advanced technologies that may reduce the cost of energy (COE) from wind turbines. The initial step in the WindPACT program is a series of preliminary scaling studies intended to determine the optimum sizes for future turbines, help define sizing limits for certain critical technologies, and explore the potential for advanced technologies to contribute to reduced COE as turbine scales increase. This report documents the results of Technical Area 2—Turbine Rotor and Blade Logistics. For this report, we investigated the transportation, assembly, and crane logistics and costs associated with installation of a range of multi-megawatt-scale wind turbines. We focused on using currently available equipment, assembly techniques, and transportation system capabilities and limitations to hypothetically transport and install 50 wind turbines at a facility in south-central South Dakota.

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